Bacteria and Sediment TMDLs
for
Mossy Creek and Long Glade Run

Final Public Meeting

March 2, 2004

Project Personnel

- Brian Benham
- Kevin Brannan
- Kim Christophel
- Theo Dillaha
- Leigh-Anne Henry
- Saied Mostaghimi
- Rachel Wagner
- Jeff Wynn
- Gene Yagow
- Rebecca Zeckoski

Overview of Today's Presentation:

- Recap of Information from the First Public Meeting

- Discuss the TMDL Study
  - Identify/quantify potential bacteria sources
  - Link sources to the stream
  - Load Allocations → the TMDL
  - Alternative TMDL Scenarios

Summary of the First Public Meeting

June 3, 2003

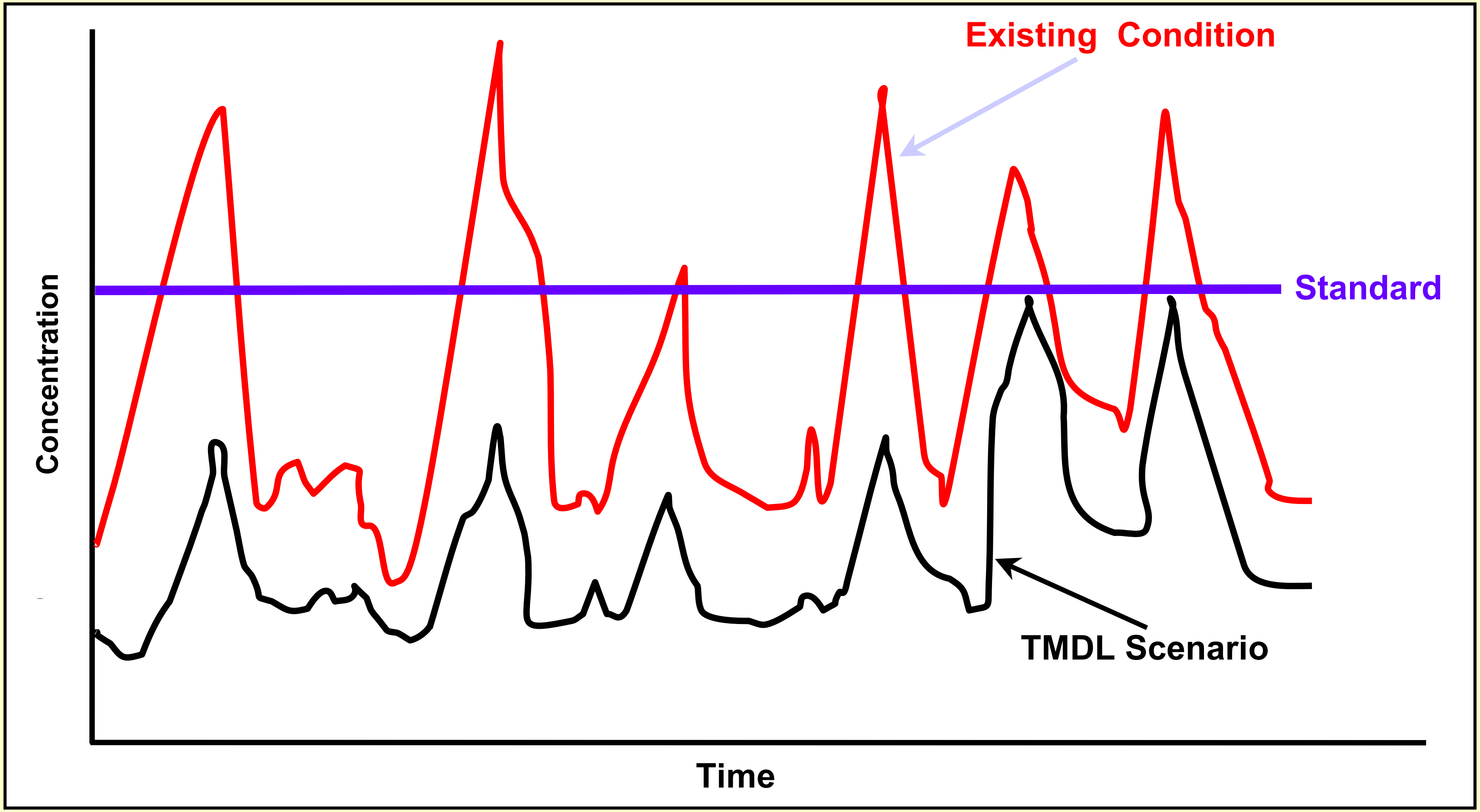
What is a TMDL?

- The maximum amount of pollutant that can enter a water body without negatively affecting its beneficial uses
  - Fishing, swimming, wildlife habitat, aquatic life, shellfish habitat

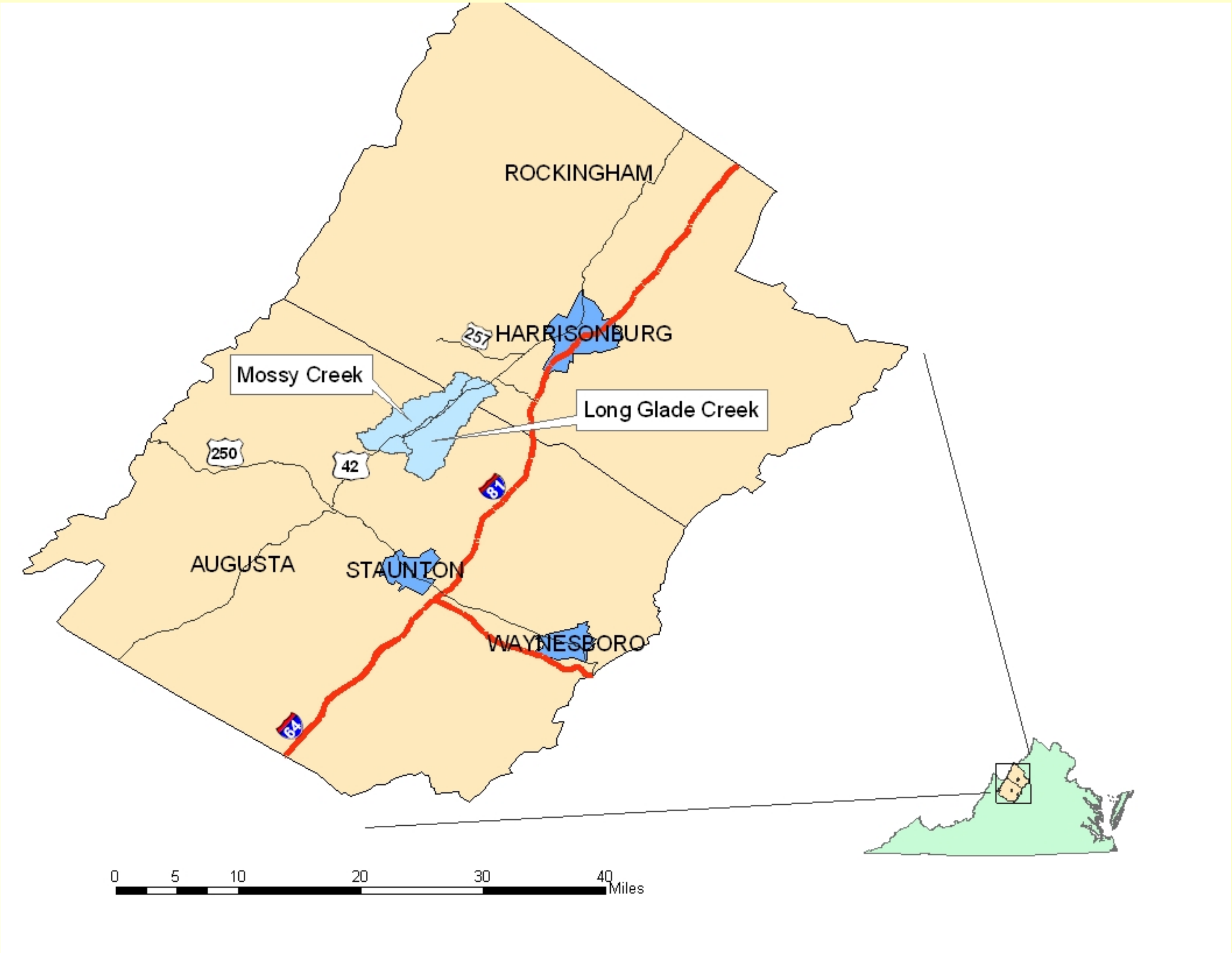
TMDL = point sources + nonpoint sources + margin of safety

= WLA + LA + MOS

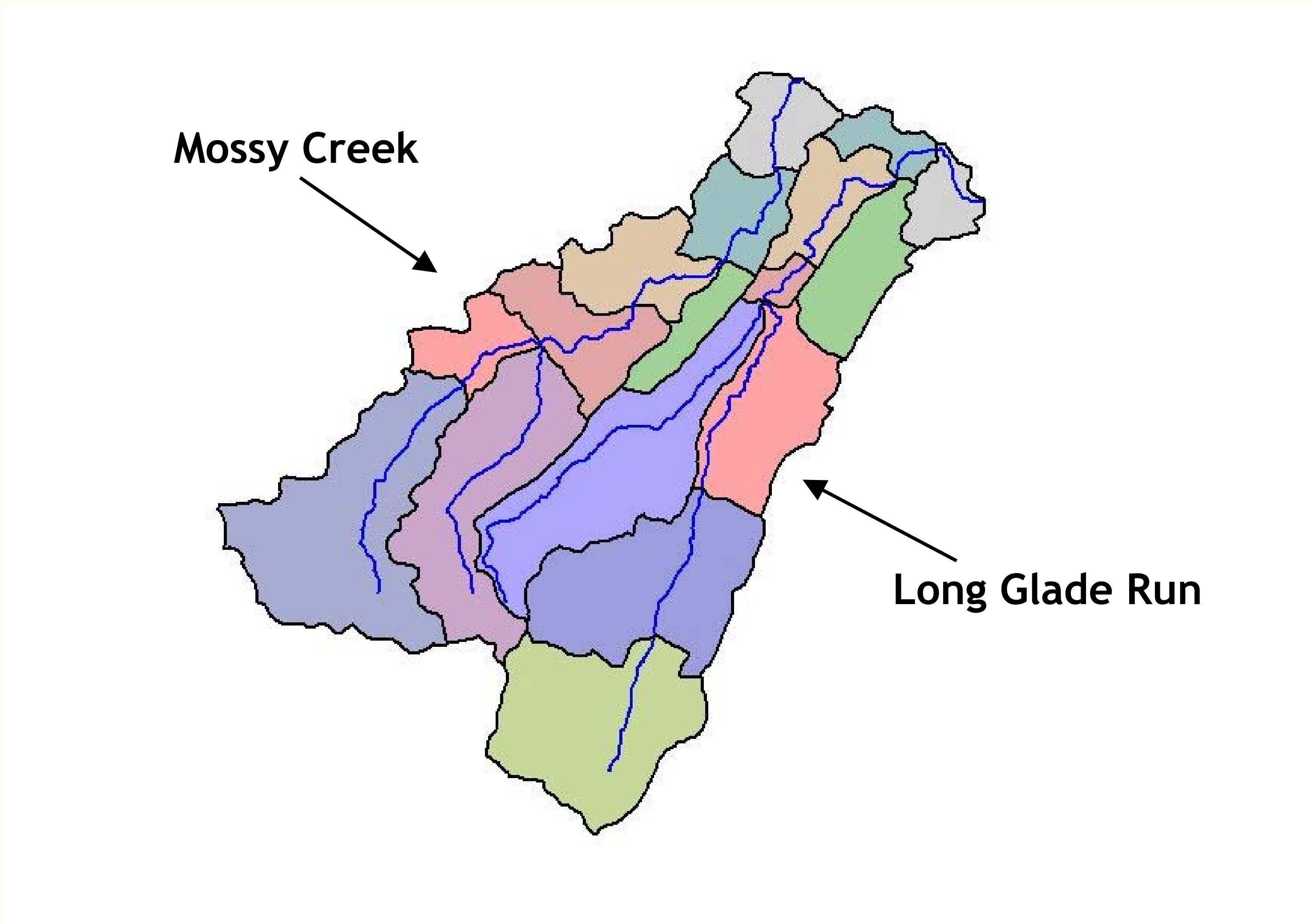
Example Bacteria TMDL



Watershed Locations

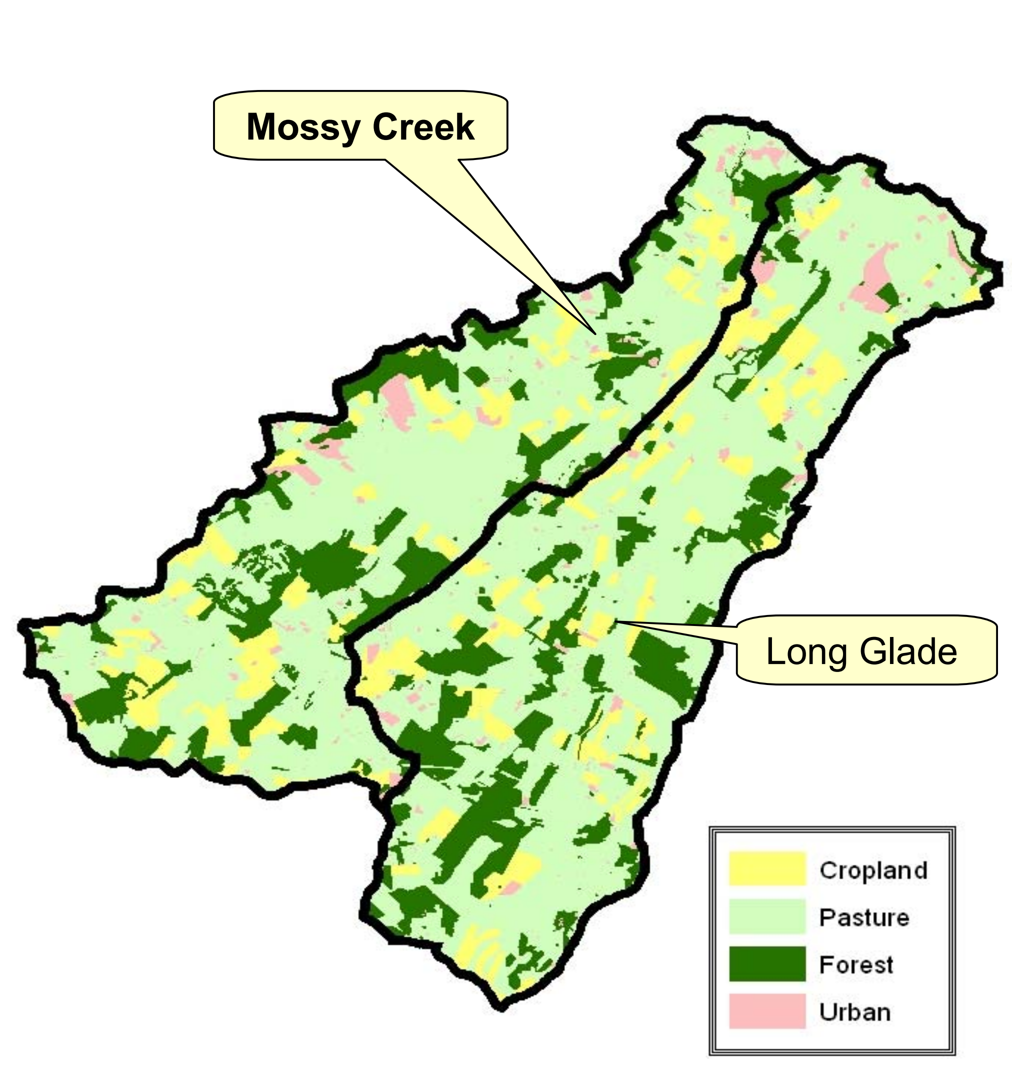


Stream Network and Subwatersheds



Major Land Uses: Long Glade and Mossy Creek

	Mossy Creek	Long Glade
Cropland	14%	15%
Forest	25%	22%
Pasture	58%	60%
Residential	4%	3%
Acreage	10,077	11,781



Impairments

- Mossy Creek has two impairments:
  - Bacteria Impairment
  - Benthic Impairment due to Excess Sediment
- Long Glade has one impairment:
  - Bacteria Impairment

Bacteria Impairment

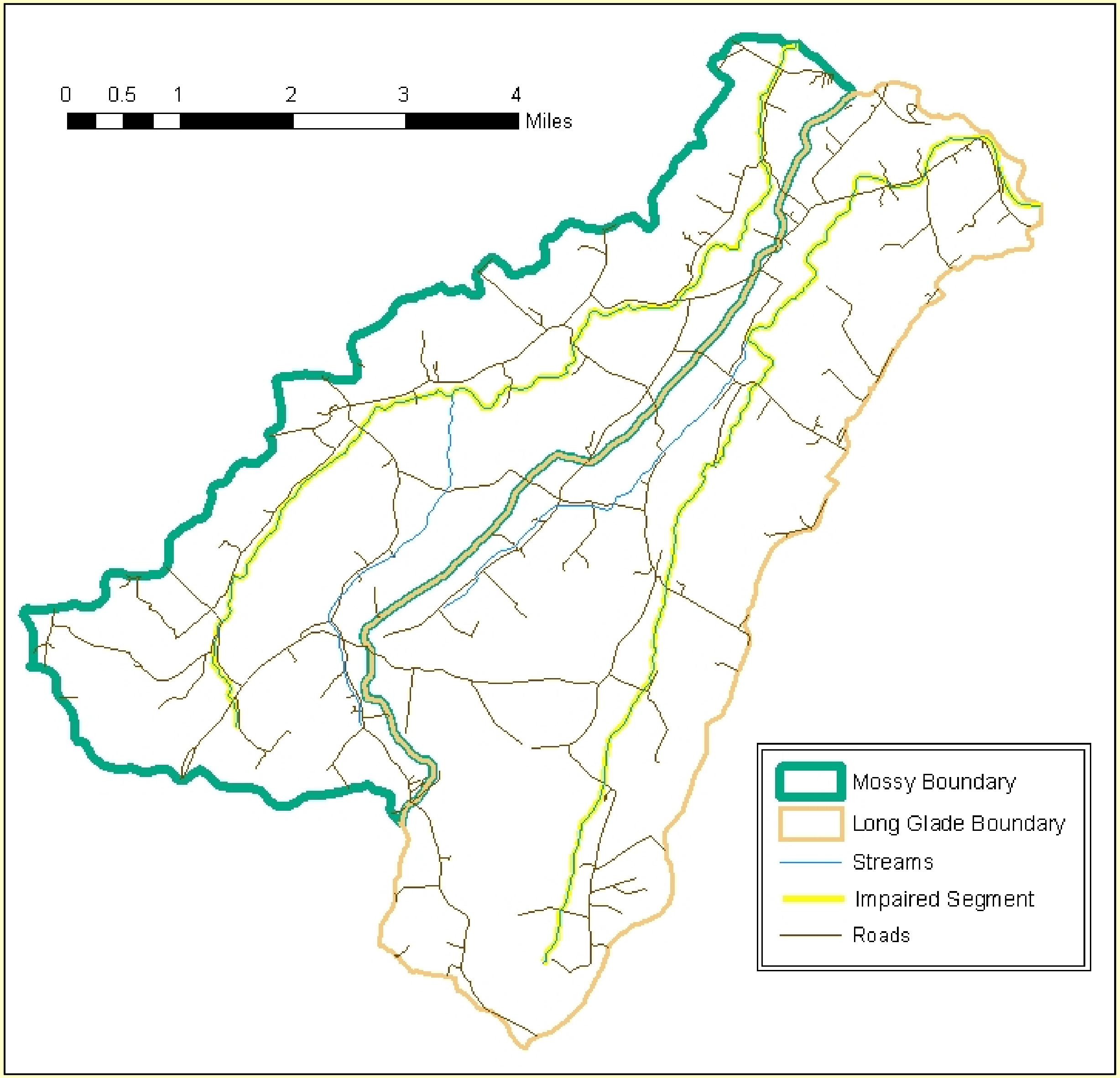
What are fecal bacteria?

Bacteria present in the intestines of warm blooded animals, e.g. humans, livestock, wildlife, and birds.

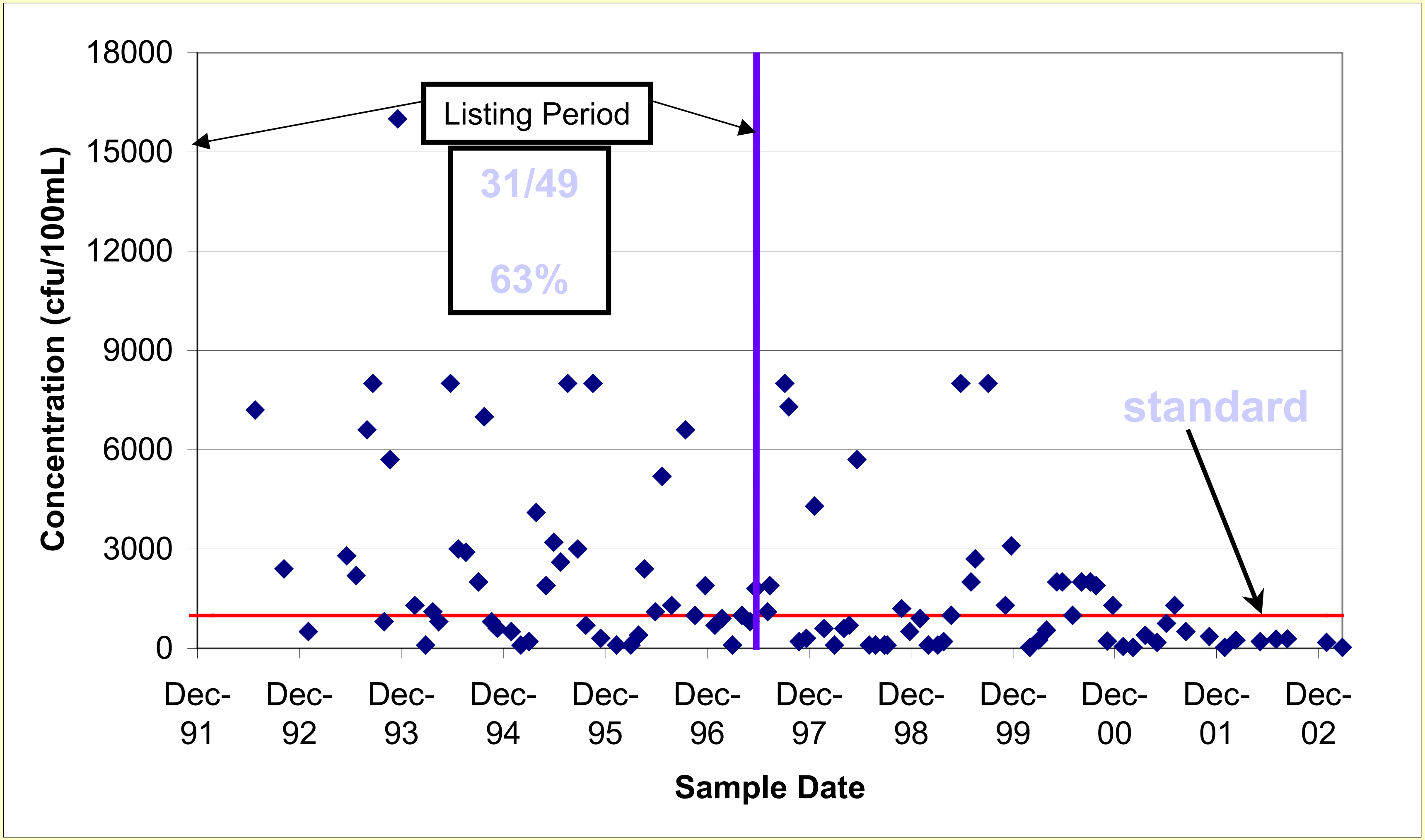
Why sample for fecal bacteria?

Indicator of the potential presence of pathogens in water bodies.

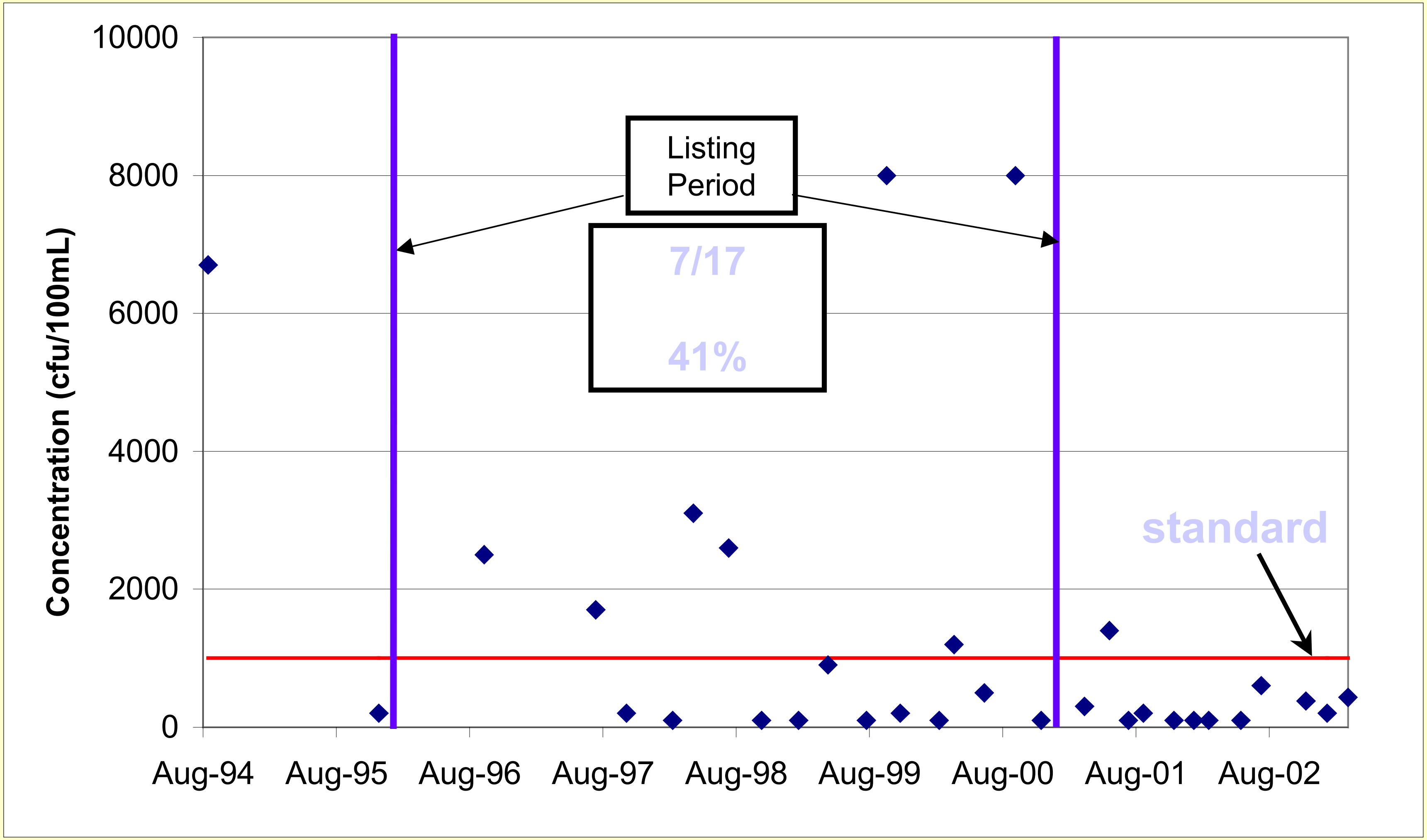
Impaired Segments



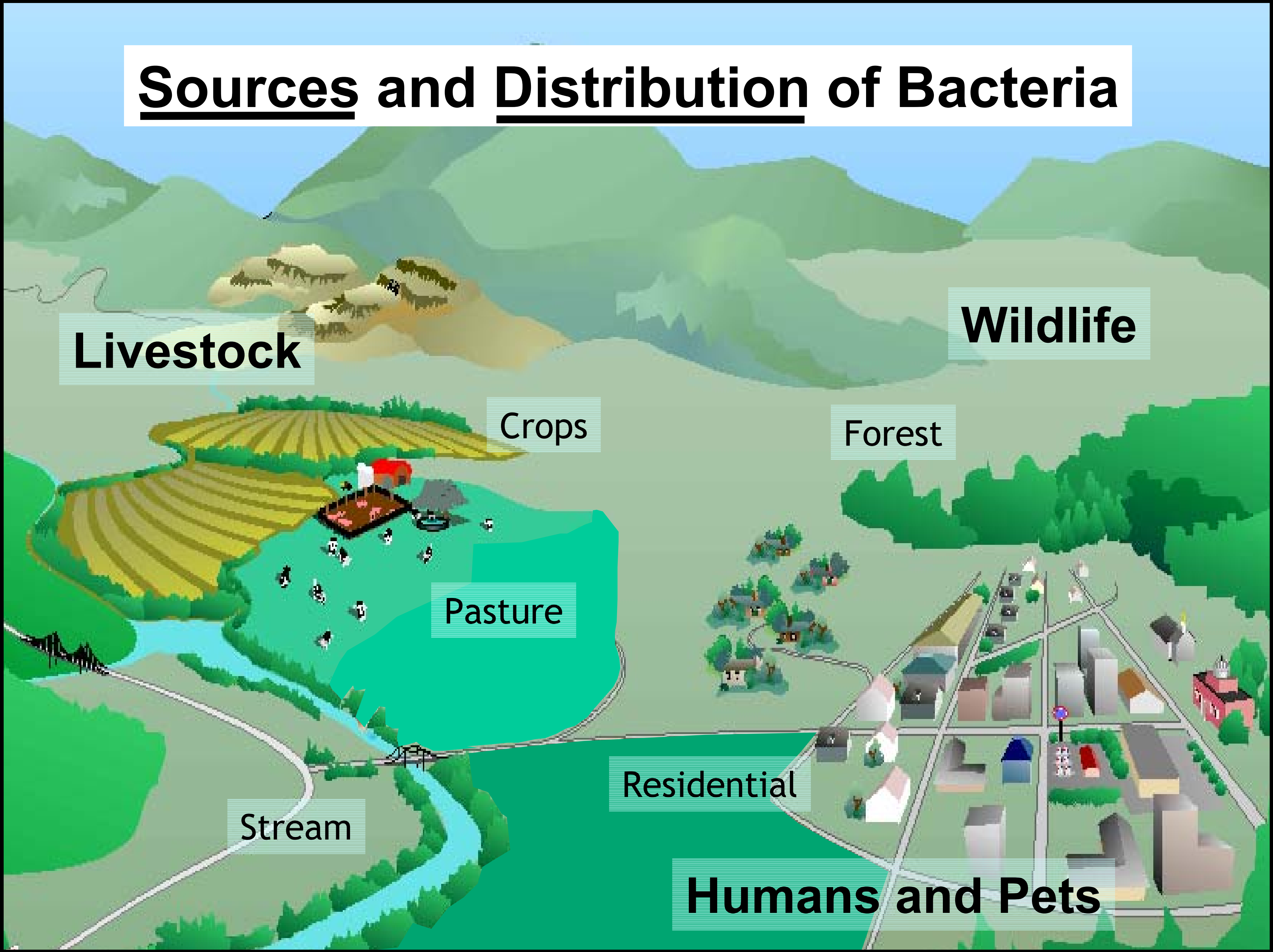
Mossy Creek Fecal Coliform Counts

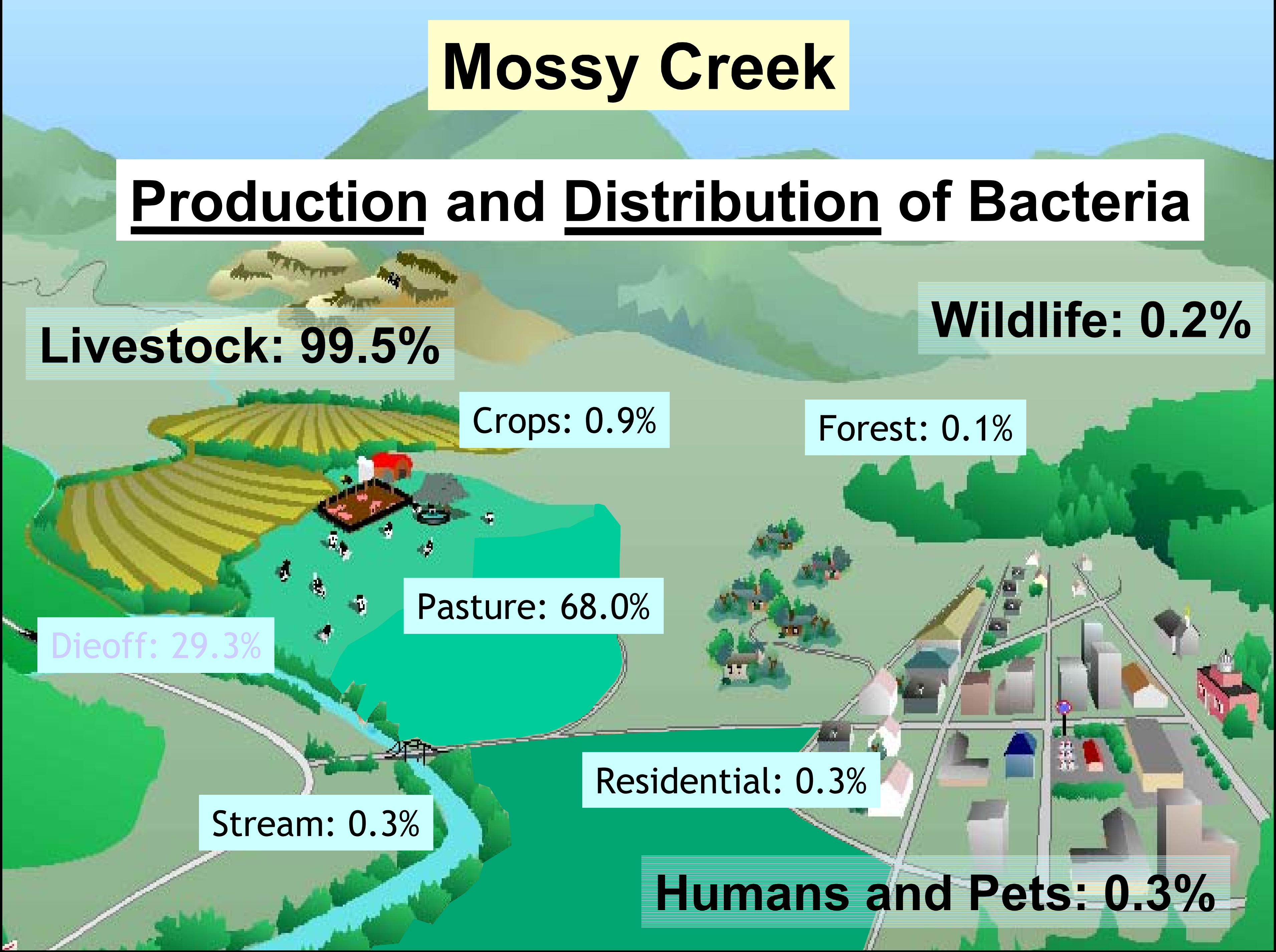


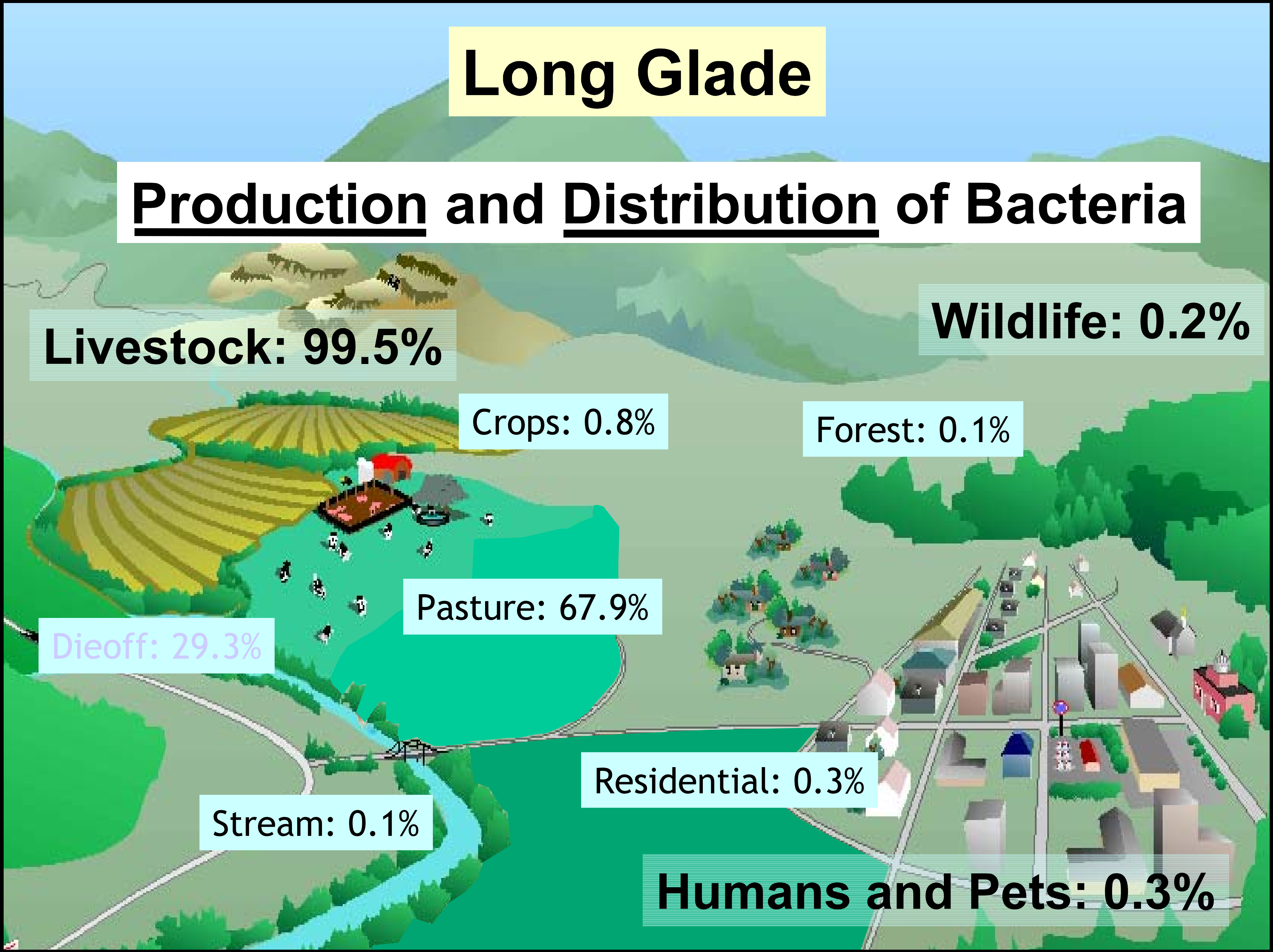
Long Glade Fecal Coliform Counts



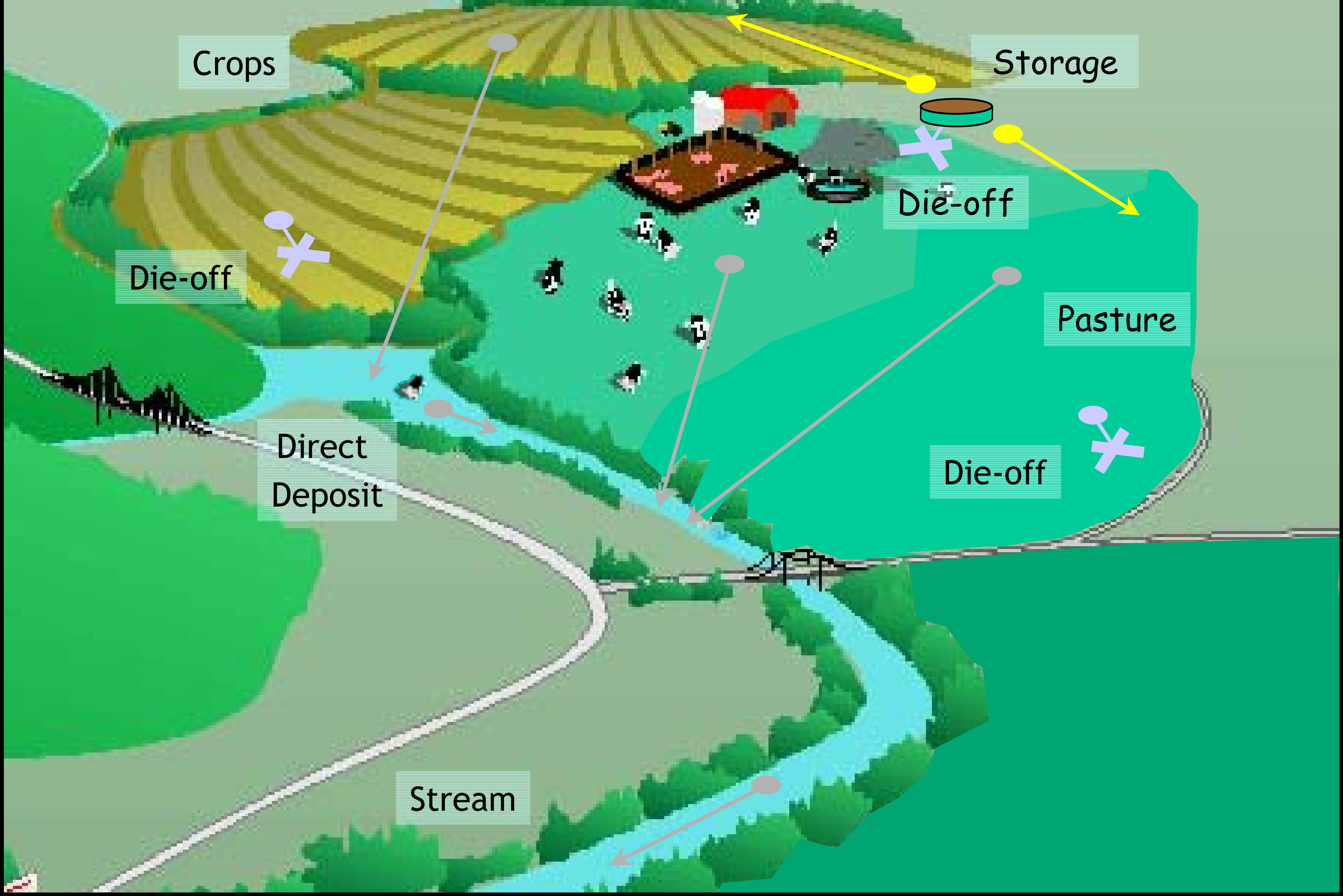
Sources and Distribution of Bacteria



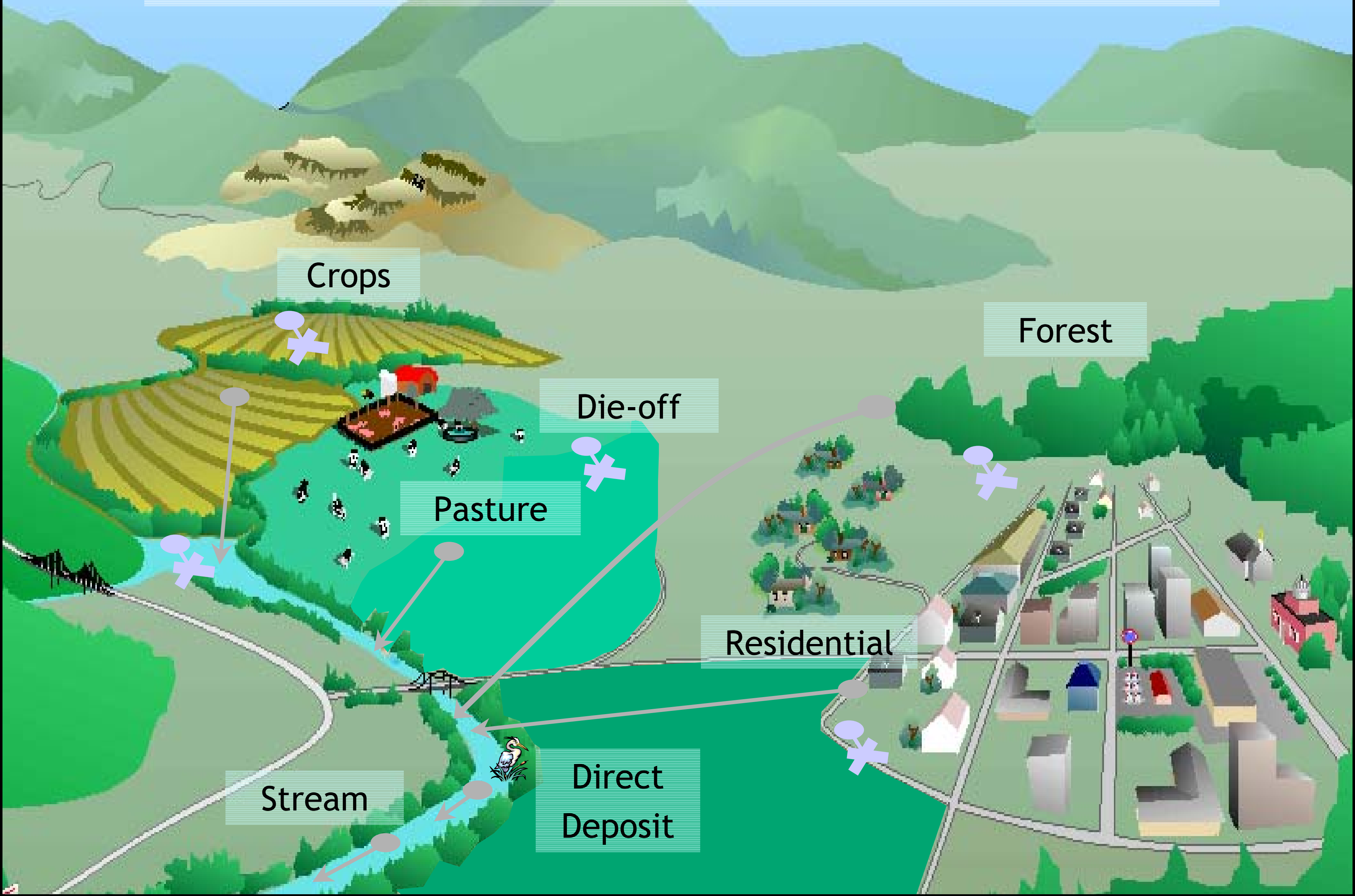

Mossy Creek
Production and Distribution of Bacteria
Livestock: 99.5%
Wildlife: 0.2%
Crops: 0.9%
Forest: 0.1%
Pasture: 68.0%
Dieoff: 29.3%
Residential: 0.3%
Stream: 0.3%
Humans and Pets: 0.3%


Long Glade
Production and Distribution of Bacteria
Livestock: 99.5%
Wildlife: 0.2%
Crops: 0.8%
Forest: 0.1%
Pasture: 67.9%
Dieoff: 29.3%
Residential: 0.3%
Stream: 0.1%
Humans and Pets: 0.3%

Fate and Transport of Bacteria: Livestock

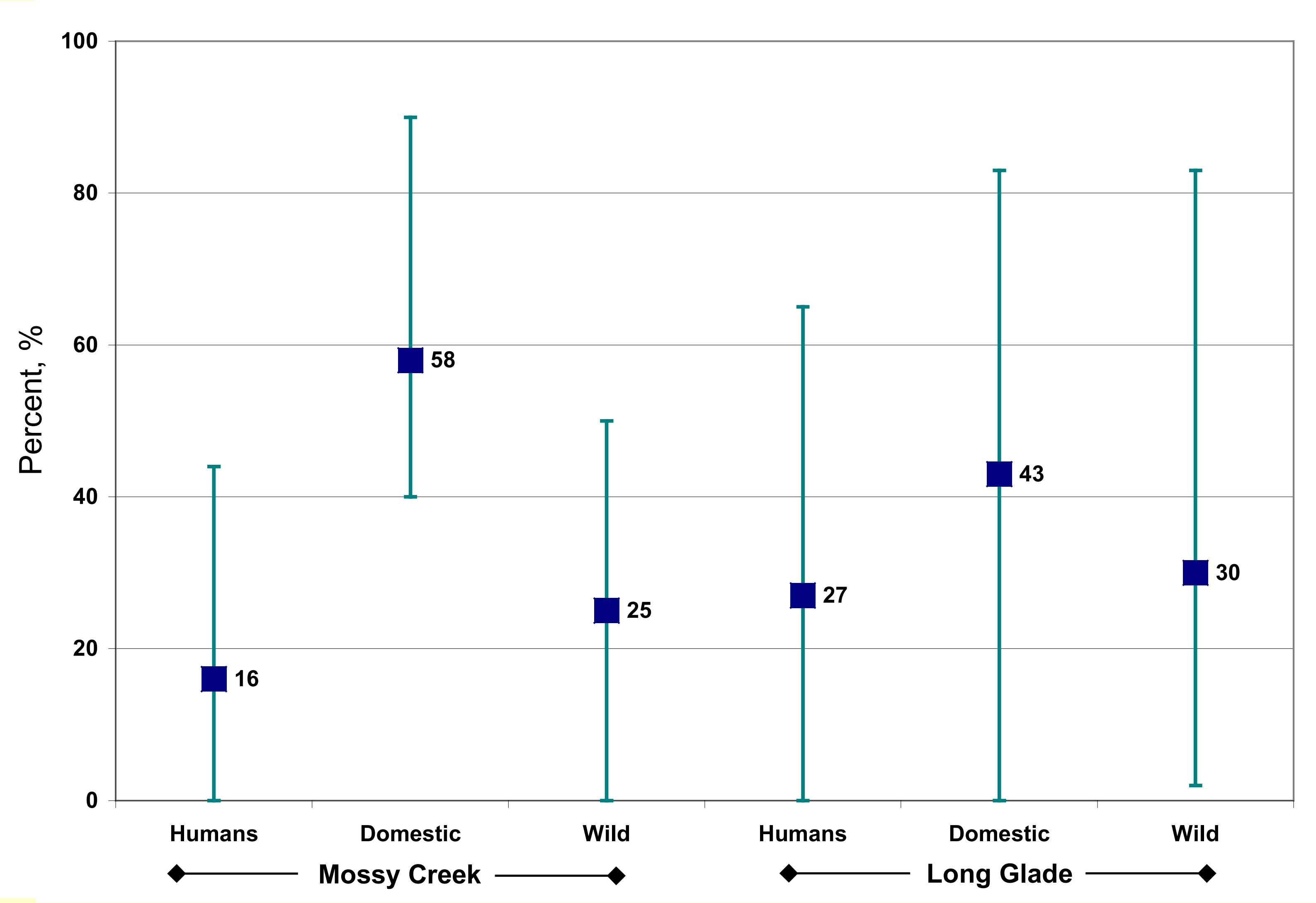


Fate and Transport of Bacteria: Wildlife



Fate and Transport of Bacteria: Humans and Pets

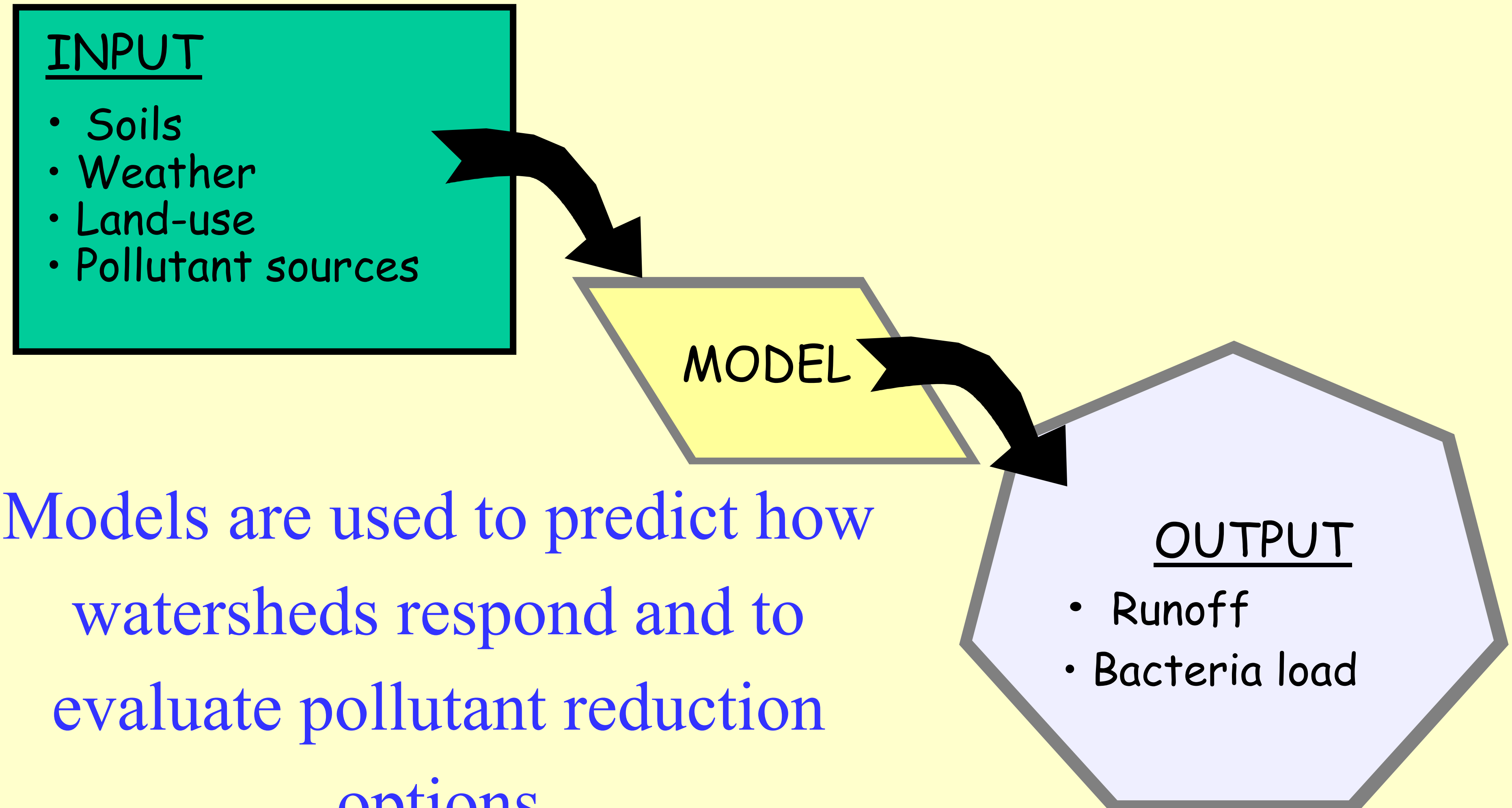
BST Results



100
80
60
40
20
0
Percent, %
58
16
25
27
43
30
Humans
Domestic
Wild
Humans
Domestic
Wild
Mossy Creek
Long Glade

Bacteria Impairments:
Linking Bacteria Sources
to Water Quality in the Stream

Using Computer Models to Develop TMDLs



Models are used to predict how watersheds respond and to evaluate pollutant reduction options

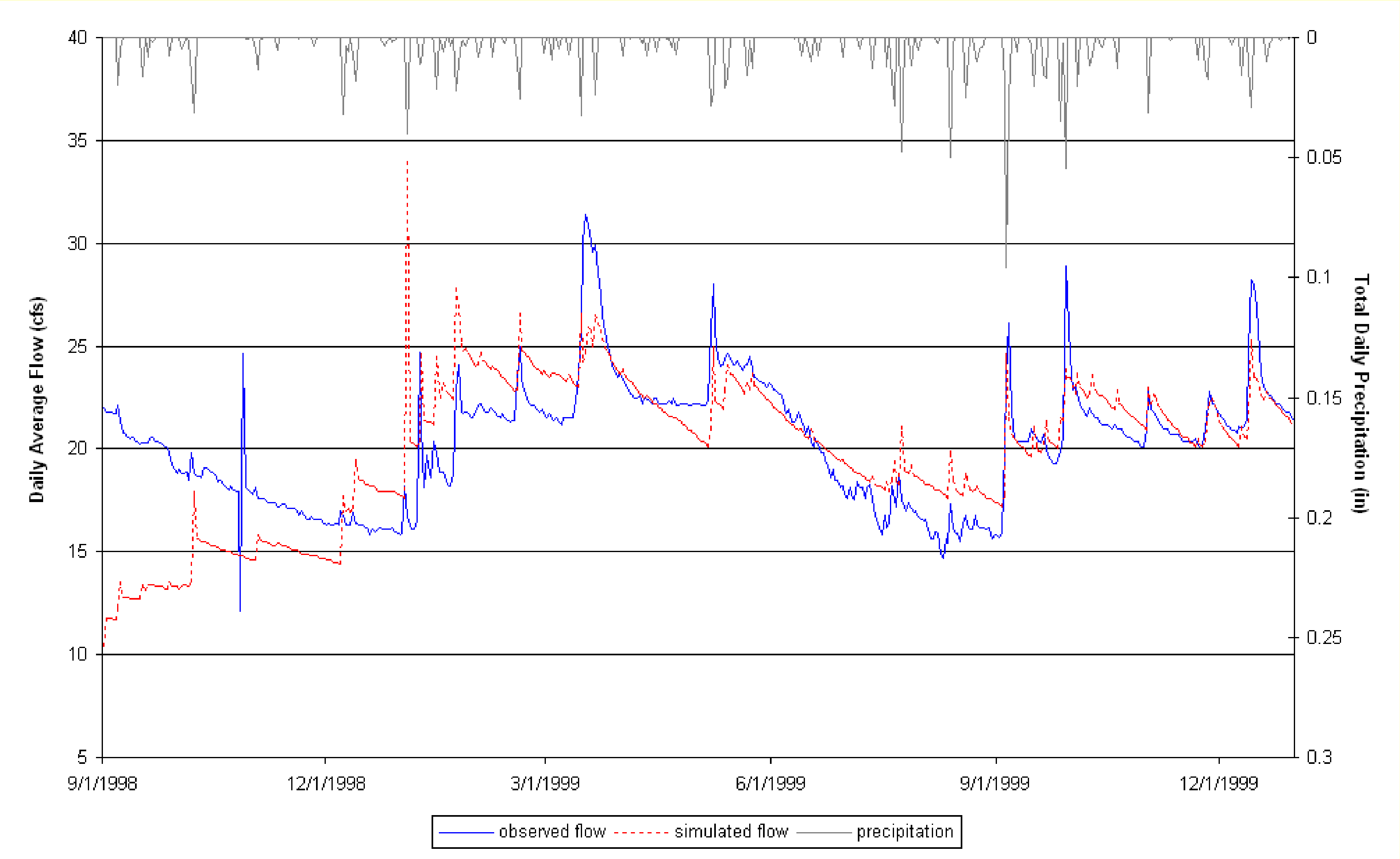
Link Sources to the Stream

- HSPF Model
  - Watershed model
  - Variability in weather
  - Point and nonpoint sources
  - Simulates fecal coliform die-off
  - Tracks fecal coliform transport from land to the stream
- Model Calibration
  - Hydrology
  - Water quality

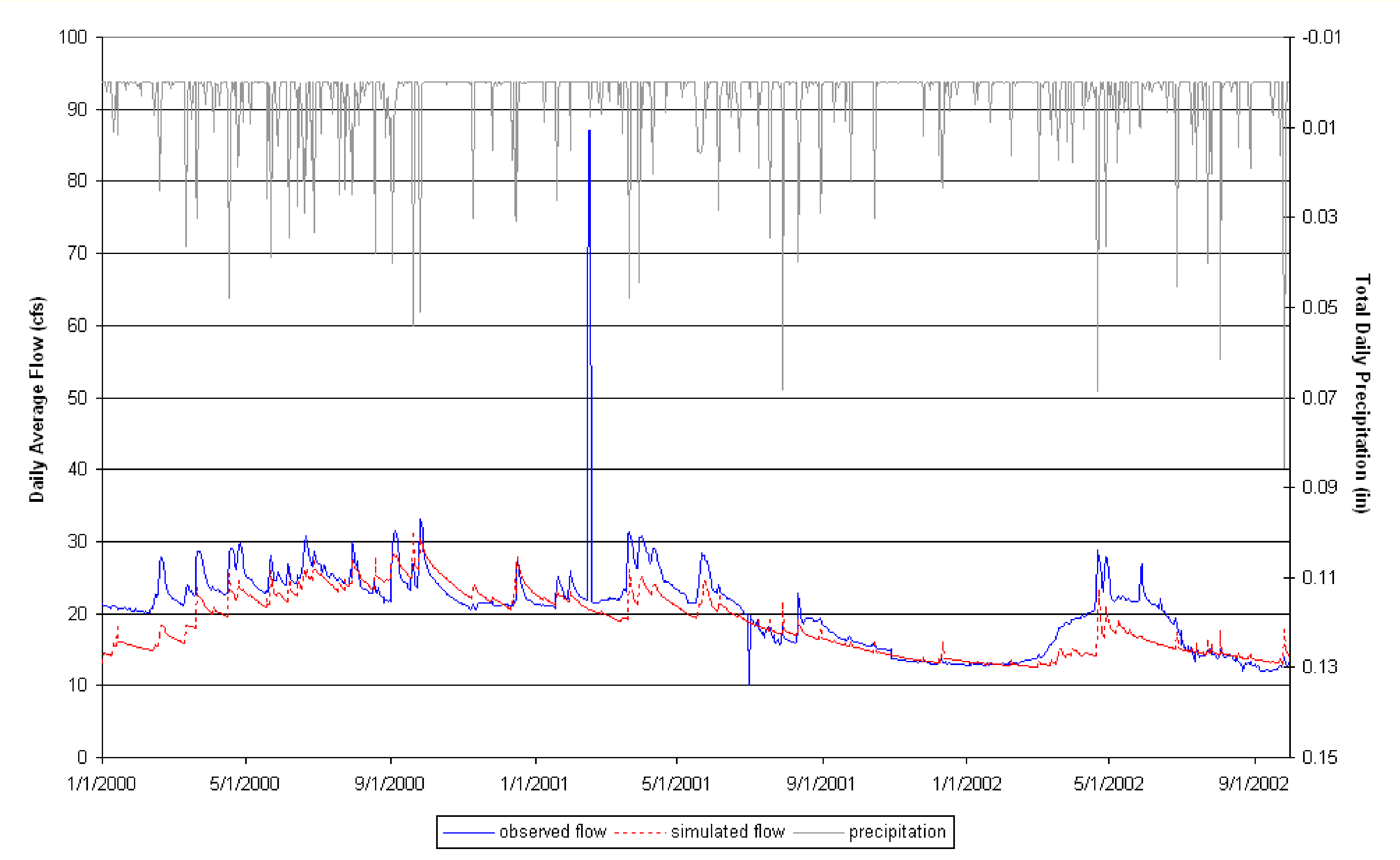
HSPF Calibration and Validation

- Calibration – Process to ensure that model accurately represents watershed conditions
  - Compare model predictions to observed data
  - Adjust model values if needed
- Validation - Process to ensure that calibrated parameters are appropriate for time periods other than the calibration period

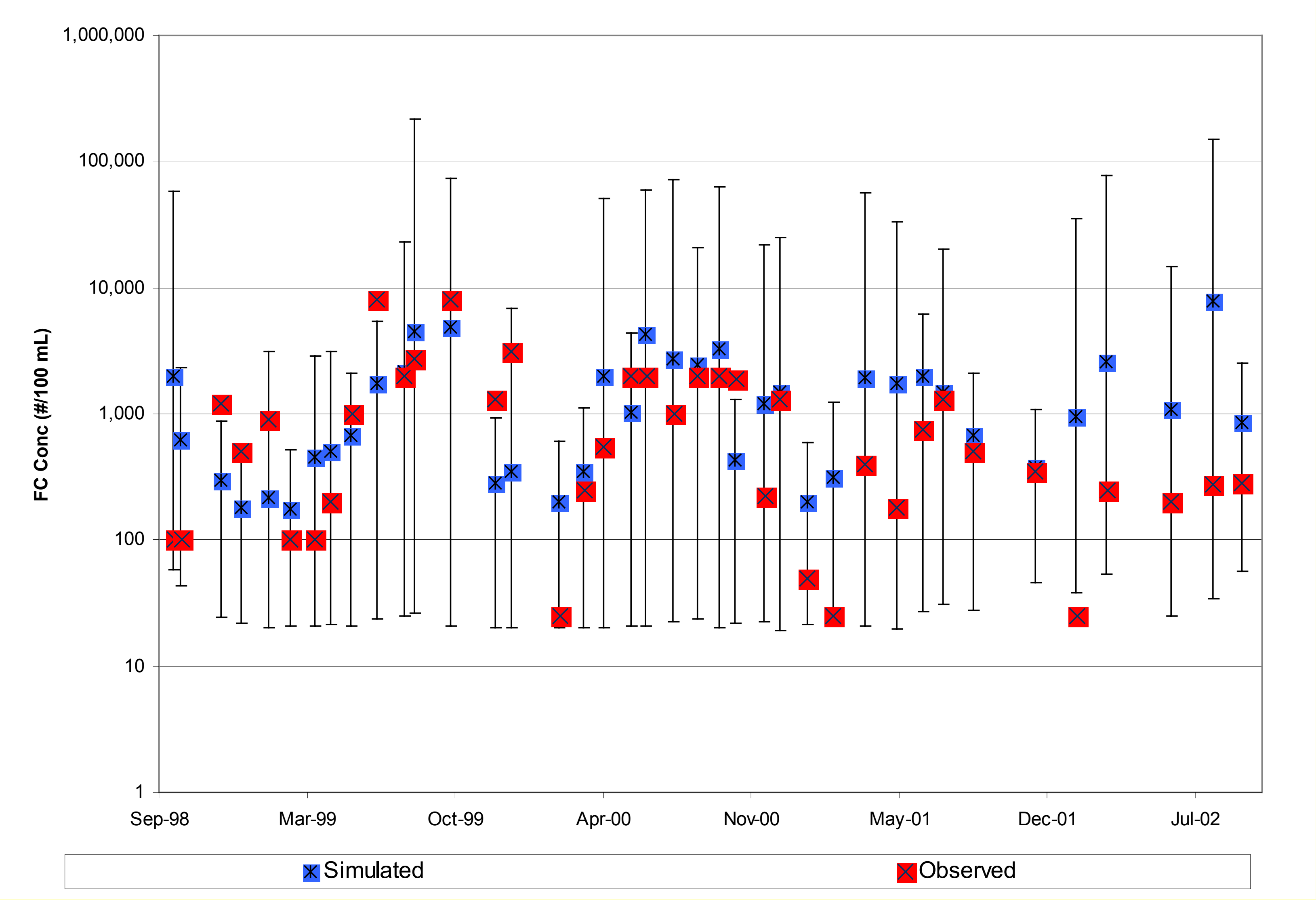
Hydrology Calibration: Mossy Creek



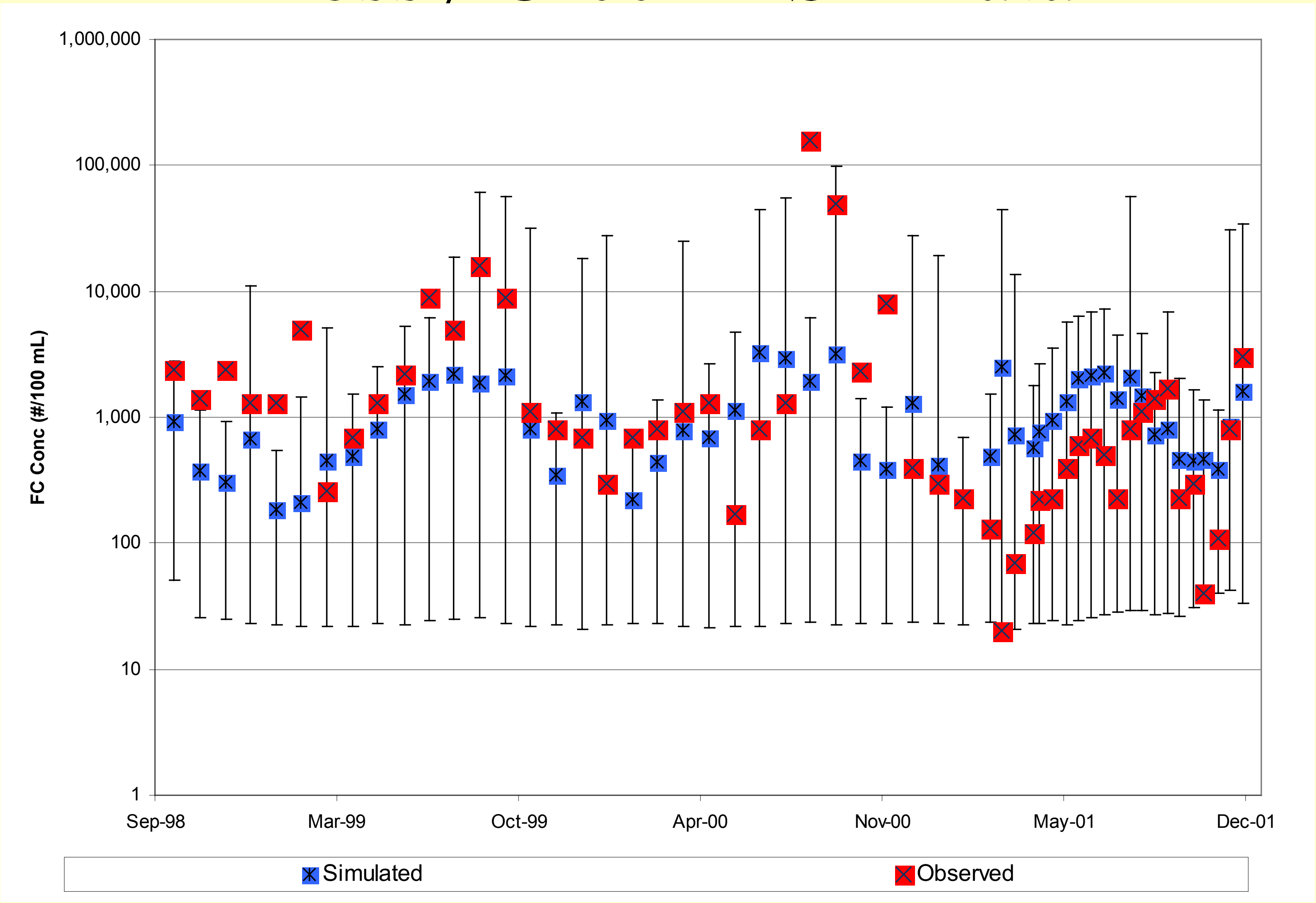
Hydrology Validation: Mossy Creek



Fecal Coliform Calibration – Mossy Creek DEQ Data



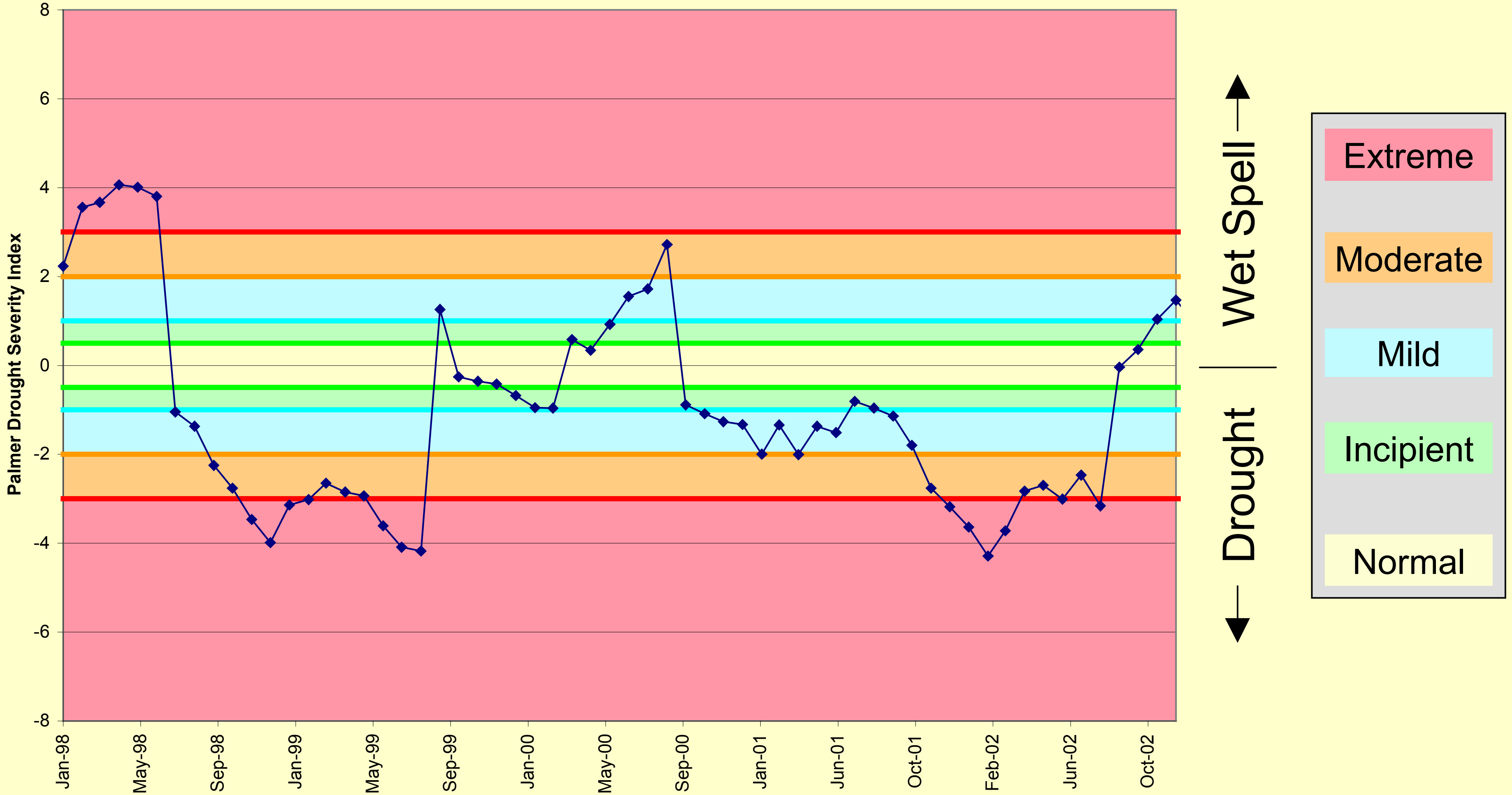
Fecal Coliform Calibration – Mossy Creek BSE Data



Drought Conditions in Long Glade Run

- Stream frequently goes dry during periods of drought
- Long Glade does not have the high spring inputs of Mossy Creek
- Due to the drought conditions during the monitoring period, little usable streamflow data was available for modeling

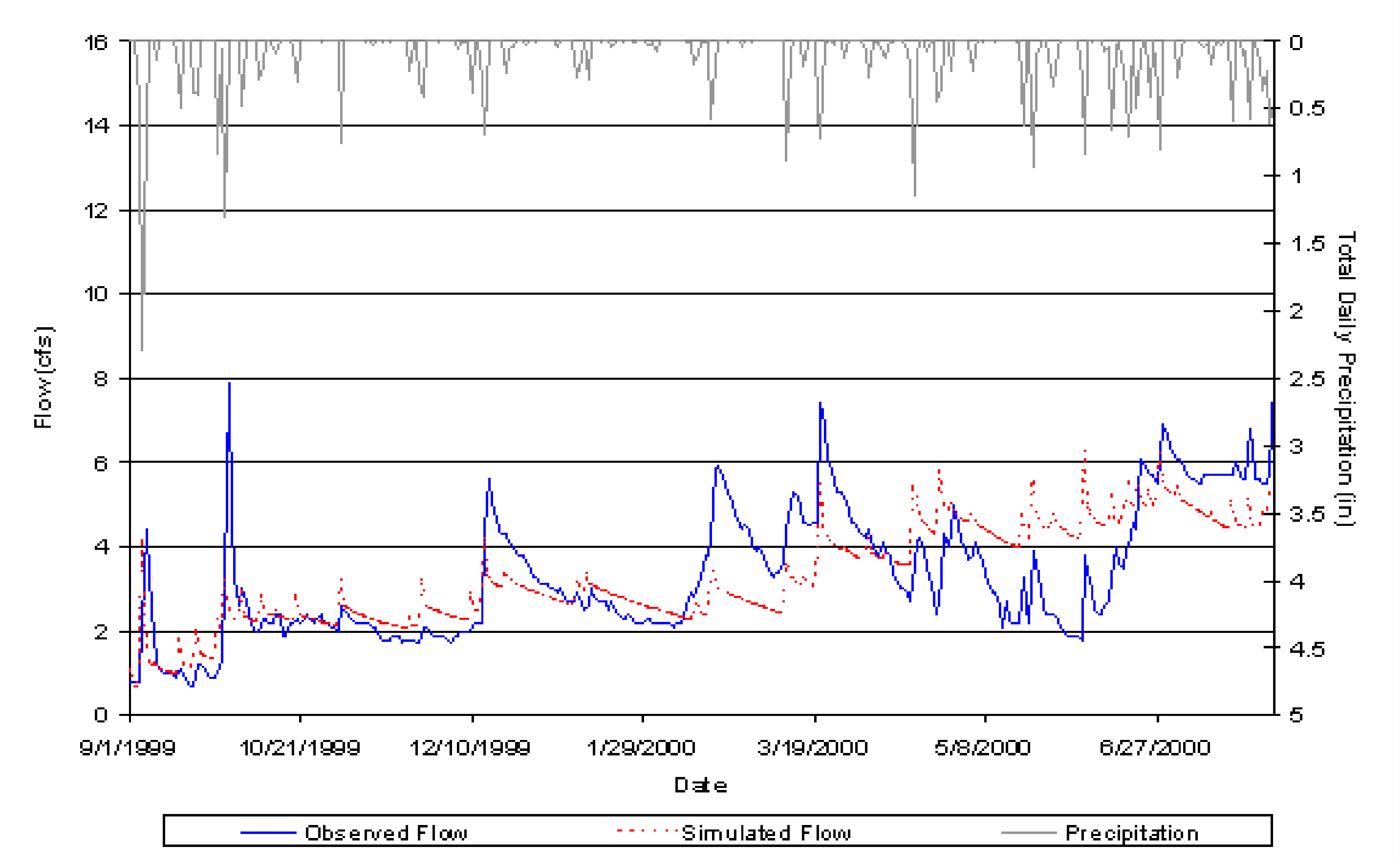
Palmer Drought Severity Index for Long Glade Run



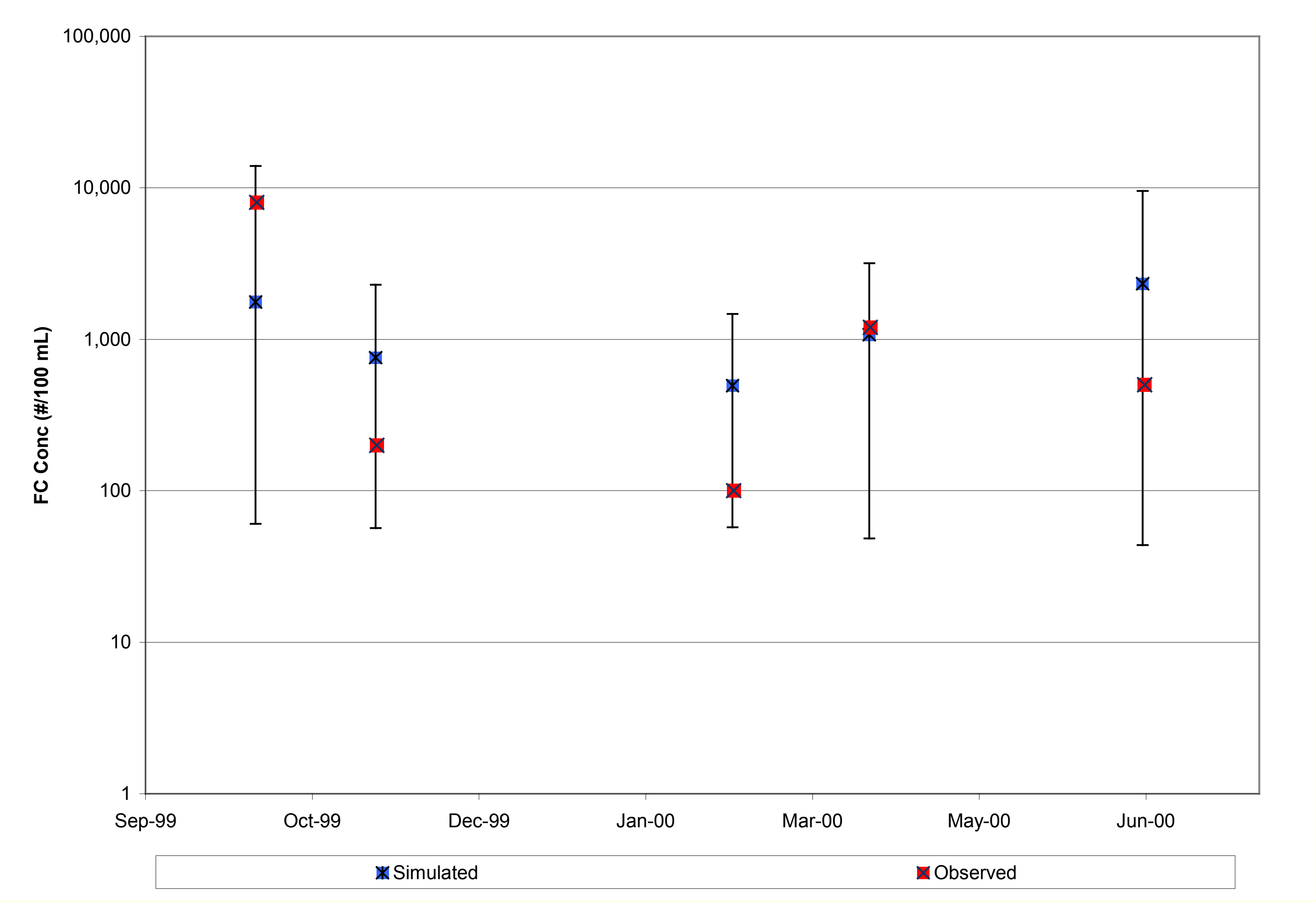
Calibration and Validation for Long Glade Run

- Longest period of consecutive normal to mild precipitation conditions was September 1999 through August 2000
  - August 2000 was removed because of suspected faulty observed values
  - This period was used for both the hydrologic and water quality calibration
- No validation period was available

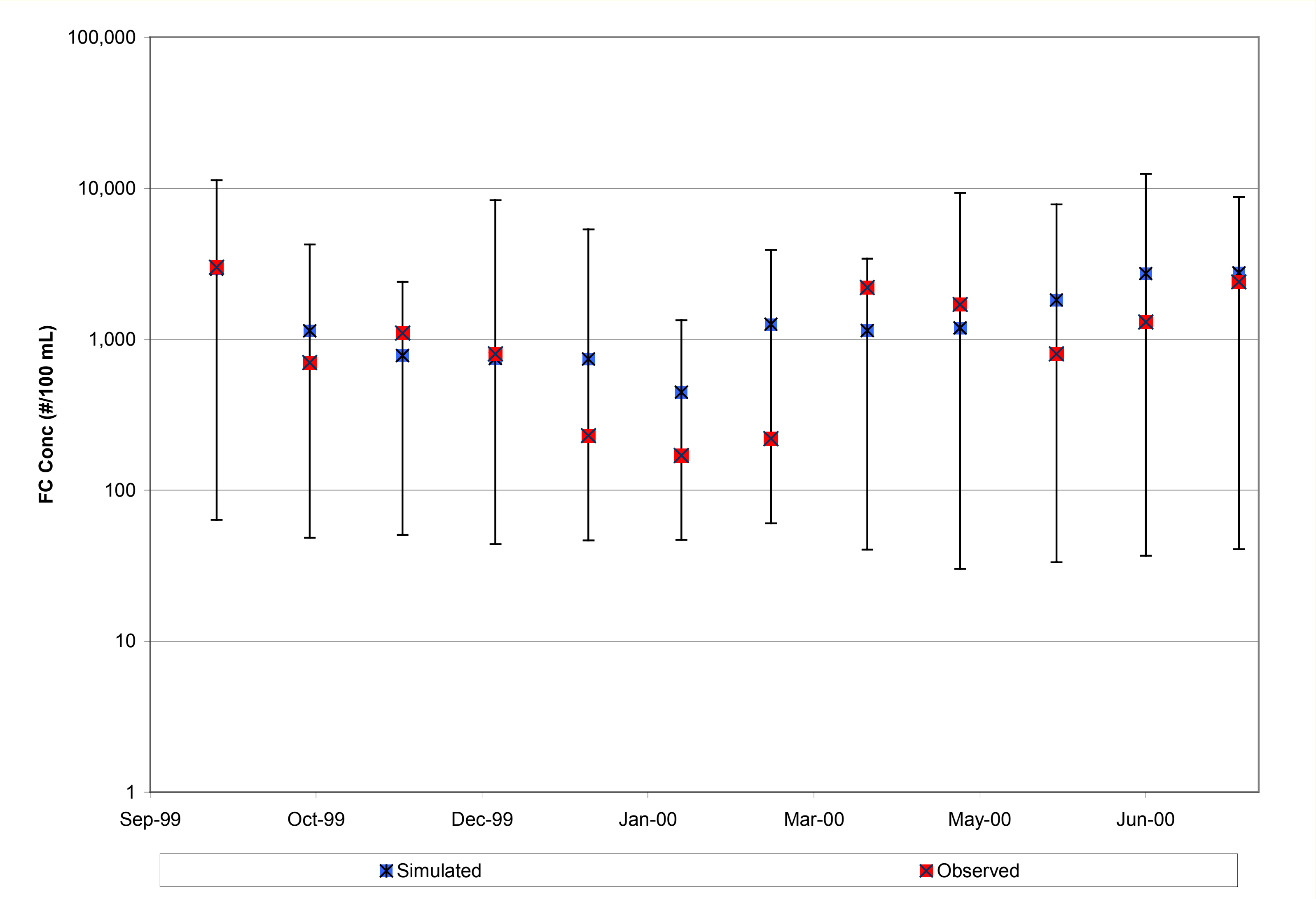
Hydrology Calibration – Long Glade Run



Fecal Coliform Calibration – Long Glade Run DEQ Data



Fecal Coliform Calibration - Long Glade Run BSE Data



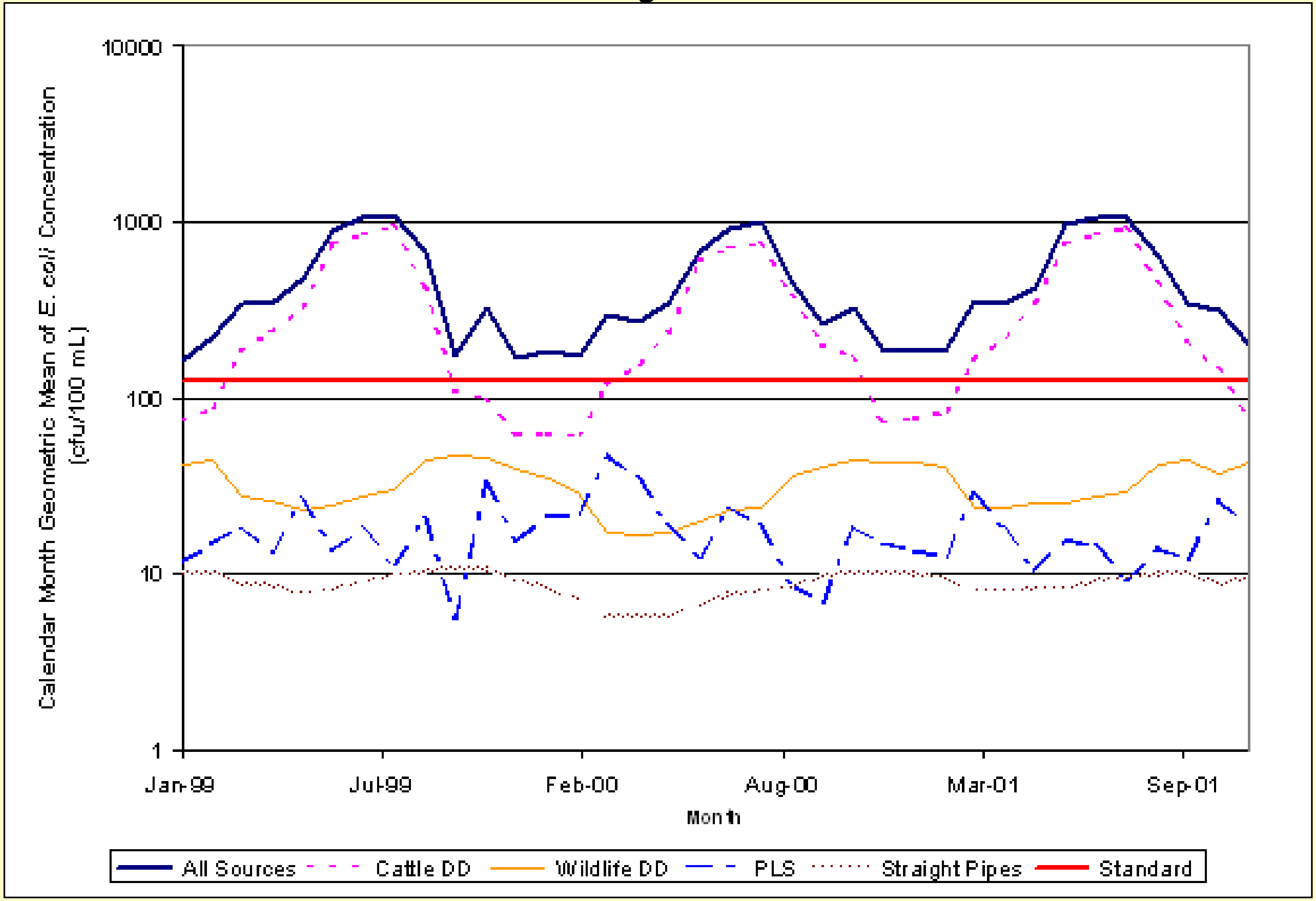
Evaluate alternative load reduction scenarios

- Task:To identify scenarios that achieve water quality standards
- Assess alternative ways to meet TMDL goal
- Consult with:
  - Local, state and federal agencies
  - Citizen groups
  - Landowners

Bacteria Load Allocation

- Identify reductions from existing sources to meet water quality standards
- Direct contributions
  - Permitted point sources
  - Animals in the stream
- Indirect contributions
  - Forest
  - Cropland
  - Pasture
  - Residential

Contribution by Source Category-Mossy Creek



Calendar-month geometric mean *E. coli* concentration

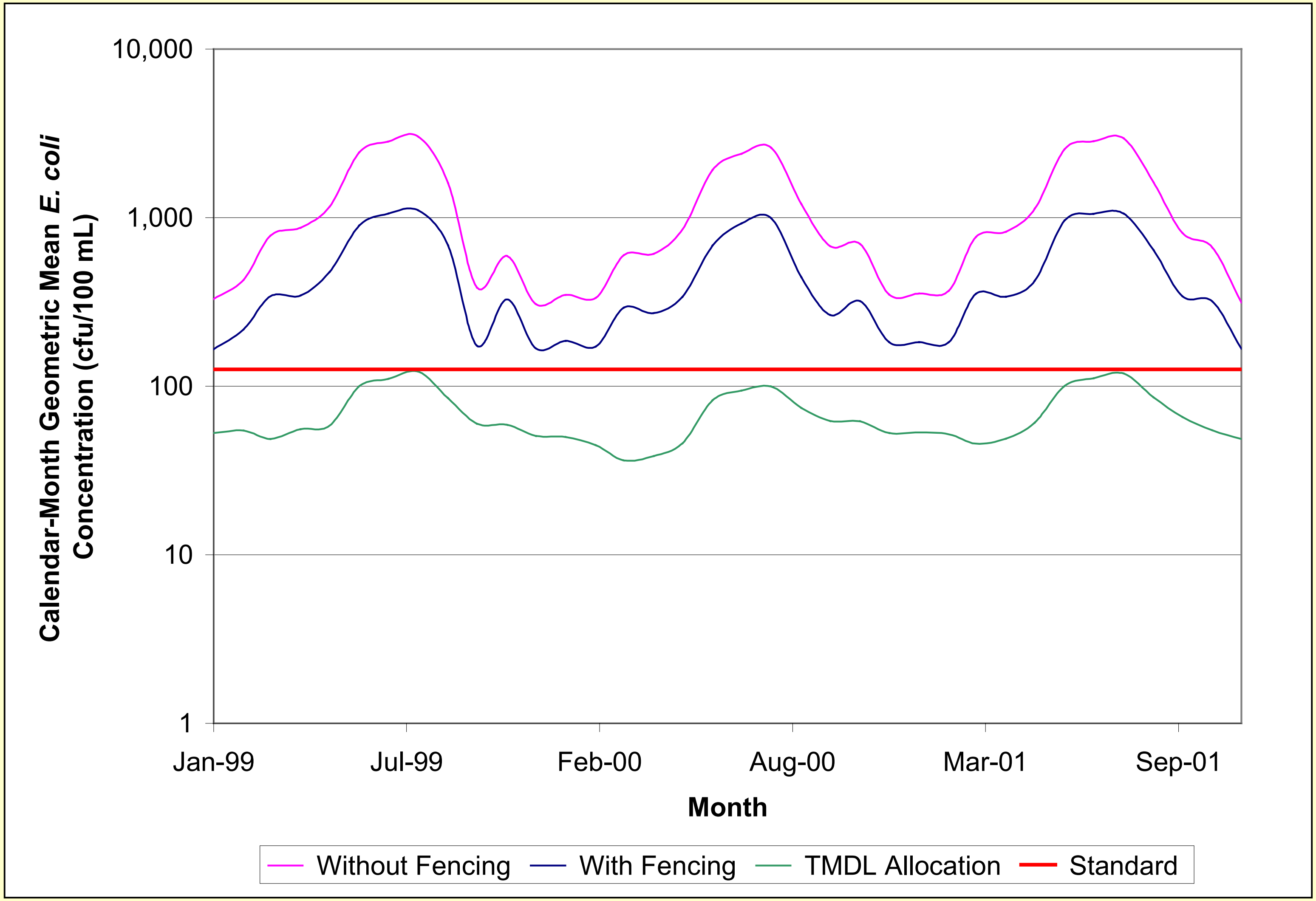
Contribution by Source Category- Mossy Creek

"Instantaneous" *E. coli* concentration

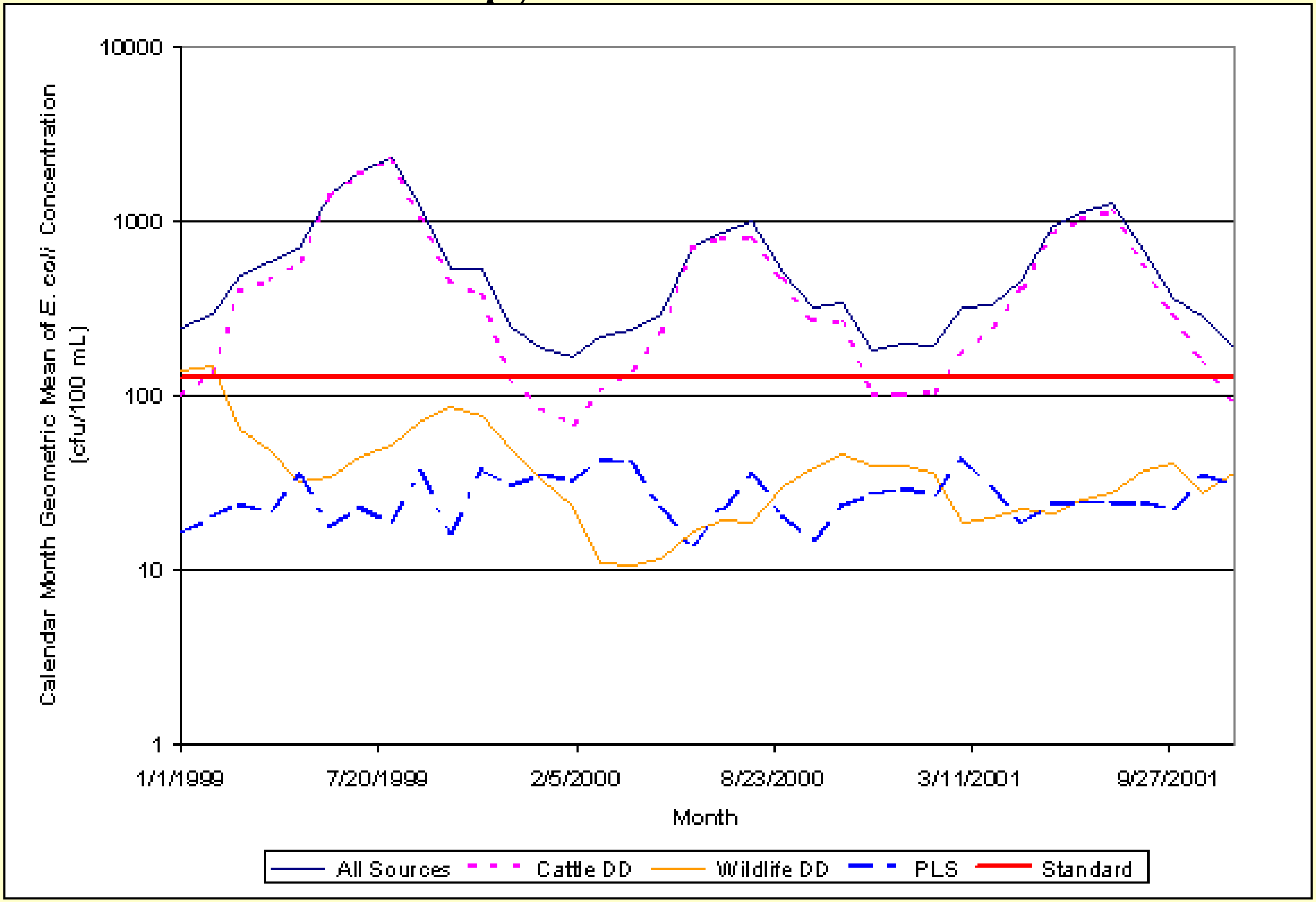
Bacteria TMDL Allocation Scenarios - Mossy Creek

Scenario Number	% Violation of *E.coli* Standard		Fecal Coliform Loading Reduction Required to Meet the *E.coli* Standards, %							
	Geo. Mean	Single Sample	Cattle DD	Cropland	Pasture	Loafing Lots	Wildlife DD	Straight Pipes	Forest PLS	All Residential PLS
Existing Conditions	100	45	0	0	0	0	0	0	0	0
01	92	44	0	50	50	100	0	100	0	50
02	0	0.1	92	95	97	100	0	100	0	95
03	0	0.1	92	95	95	100	30	100	0	95
04	0	0.1	99	95	95	100	99	100	0	95
05	0	0	99	90	98	100	30	100	0	95
06	0	0	92	95	98	100	0	100	0	95

Effect of Fencing in Mossy Creek

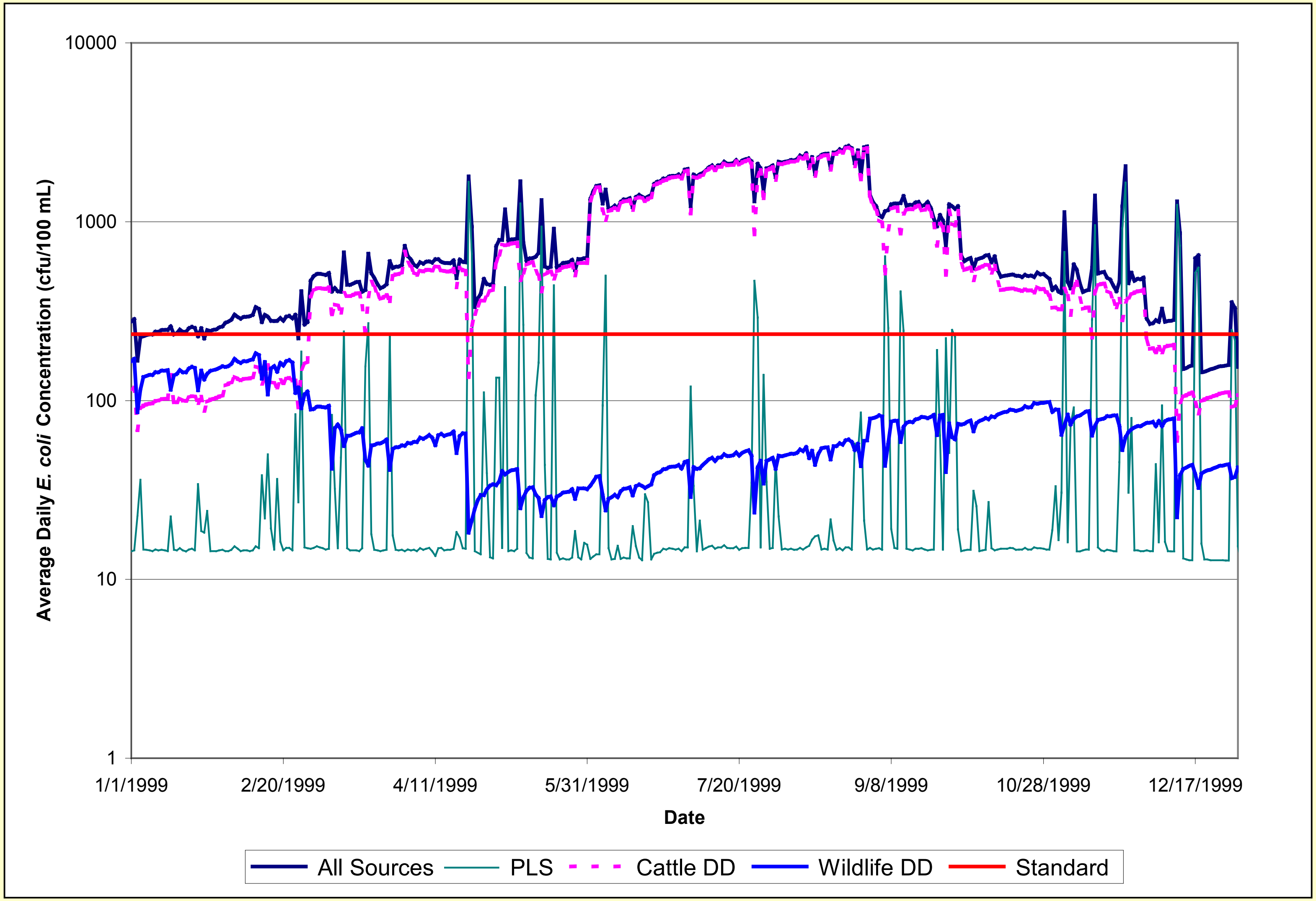


Contribution by Source Category – Long Glade Run



Calendar-month geometric mean *E. coli* concentration

Contribution by Source Category – Long Glade Run

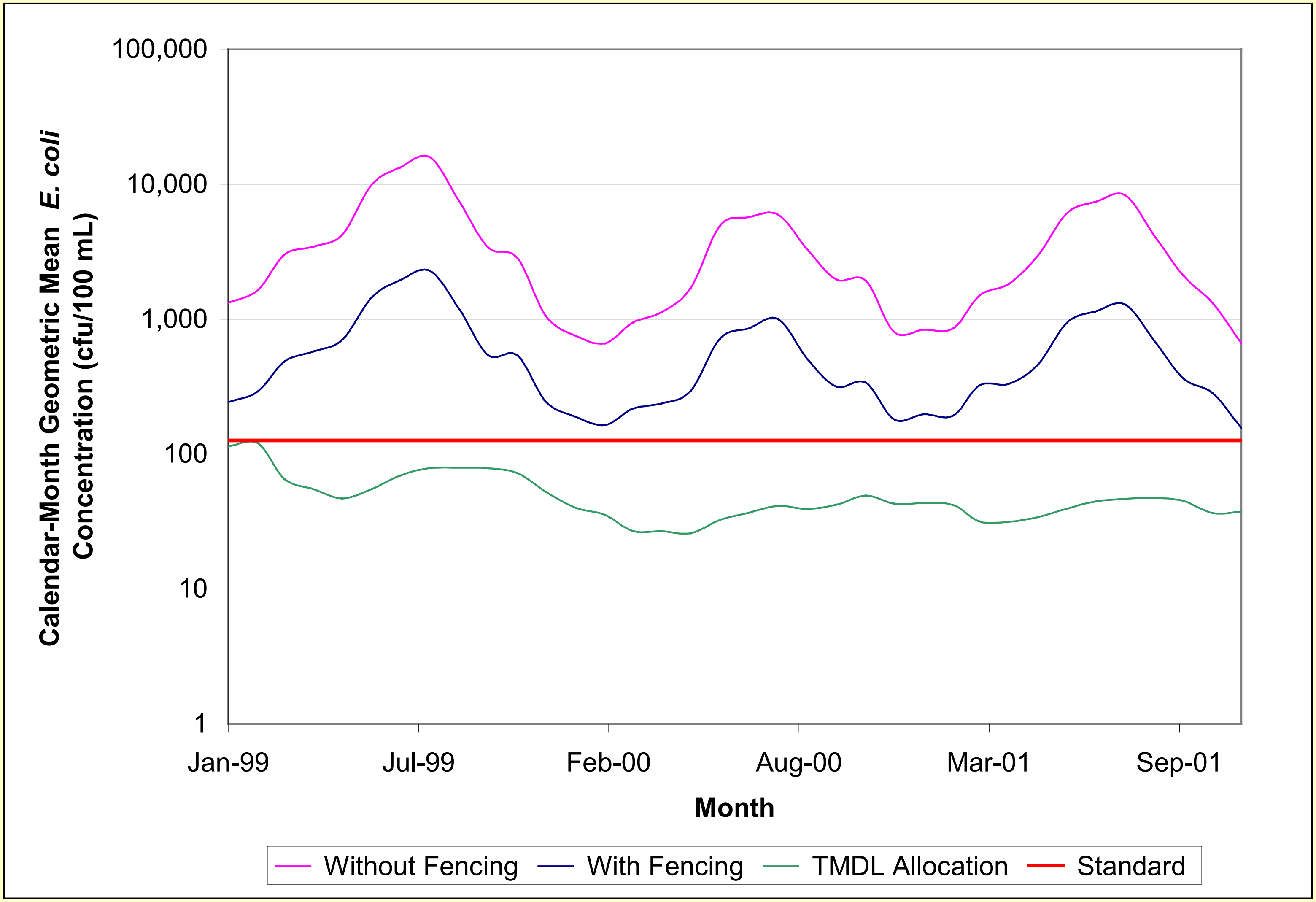


"Instantaneous" *E. coli* concentration

Bacteria TMDL Allocation Scenarios - Long Glade Run

Scenario Number	% Violation of *E.coli* Standard		Fecal Coliform Loading Reduction Required to Meet the *E.coli* Standards, %							
	Geo. Mean	Single Sample	Cattle DD	Cropland	Pasture	Loafing Lots	Wildlife DD	All ILS	Forest PLS	All Residential PLS
Existing Conditions	100	57	0	0	0	0	0	0	0	0
01	94	45	50	50	50	50	0	0	0	50
02	6	0	100	100	100	100	0	0	0	100
03	0	0.07	99	90	90	99	50	0	0	99
04	3	0	97	95	95	100	35	0	0	95
05	3	0	99	95	95	100	25	0	0	85
06	0	0.07	99	95	95	100	30	0	0	25
07	0	0	98	95	95	100	30	0	0	30
08	0	0	100	95	95	100	25	0	0	30
09	0	0	99	95	95	100	30	0	0	30

Effect of Fencing in Long Glade Run



Bacteria TMDLs

Watershed	TMDL ($x10^9$ cfu/yr)	ΣWLA ($x10^9$ cfu/yr)	ΣLA ($x10^9$ cfu/yr)	MOS*
Mossy Creek	14,232	2	14,230	--
Long Glade Run	2,320	5	2,315	--

*Implicit MOS

Stage 1 Implementation Objective

- Reduce violation rate of the instantaneous standard (235 cfu/100 mL) to 10%

- Adaptive Implementation
  - Gradual BMP implementation
  - Continuous assessment
    - Water quality monitoring

Stage 1 Implementation Scenarios-Mossy Creek

Scenario Number	% Violation of Single Sample *E. coli* Standard	Fecal Coliform Loading Reduction Required to Meet the *E.coli* Standards, %							
		Cattle DD	Cropland	Pasture	Loafing Lots	Wildlife DD	Straight Pipes	Forest PLS	All Residential PLS
TMDL Scenario	0	92	90	90	100	0	100	0	90
01	9	85	75	85	80	0	100	0	75
02	10	85	50	85	75	0	100	0	50
03	11	85	0	85	65	0	100	0	0
04	11	80	80	85	80	0	100	0	80
05	10	85	0	85	70	0	100	0	0

Stage 1 Implementation Scenarios-Long Glade Run

Scenario Number	% Violation of Single Sample *E. coli* Standard	Fecal Coliform Loading Reduction Required to Meet the *E.coli* Standards, %						
		Cattle DD	Cropland	Pasture	Loafing Lots	Wildlife DD	Forest PLS	All Residential PLS
Existing Conditions	0	99	95	95	100	30	0	30
01	0	99	90	90	100	0	0	30
02	13	85	75	75	75	0	0	30
03	12	90	60	60	60	0	0	0
04	10	90	75	75	75	0	0	30
05	10	90	65	65	65	0	0	0

Benthic Impairment
Mossy Creek

The stream does not meet the state narrative standard for biological health.

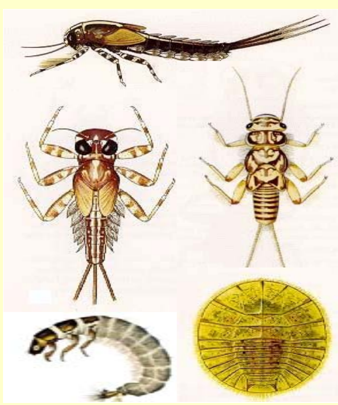
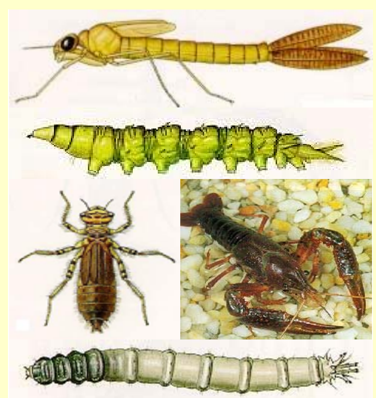
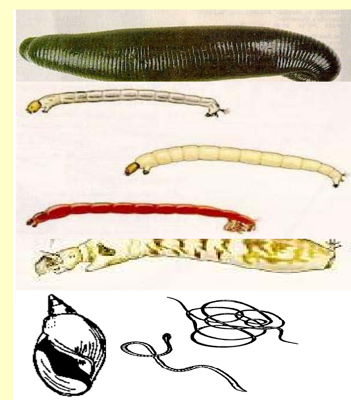
How are Benthic Impairments Determined?

- Based on semi-annual monitoring of benthic macroinvertebrates

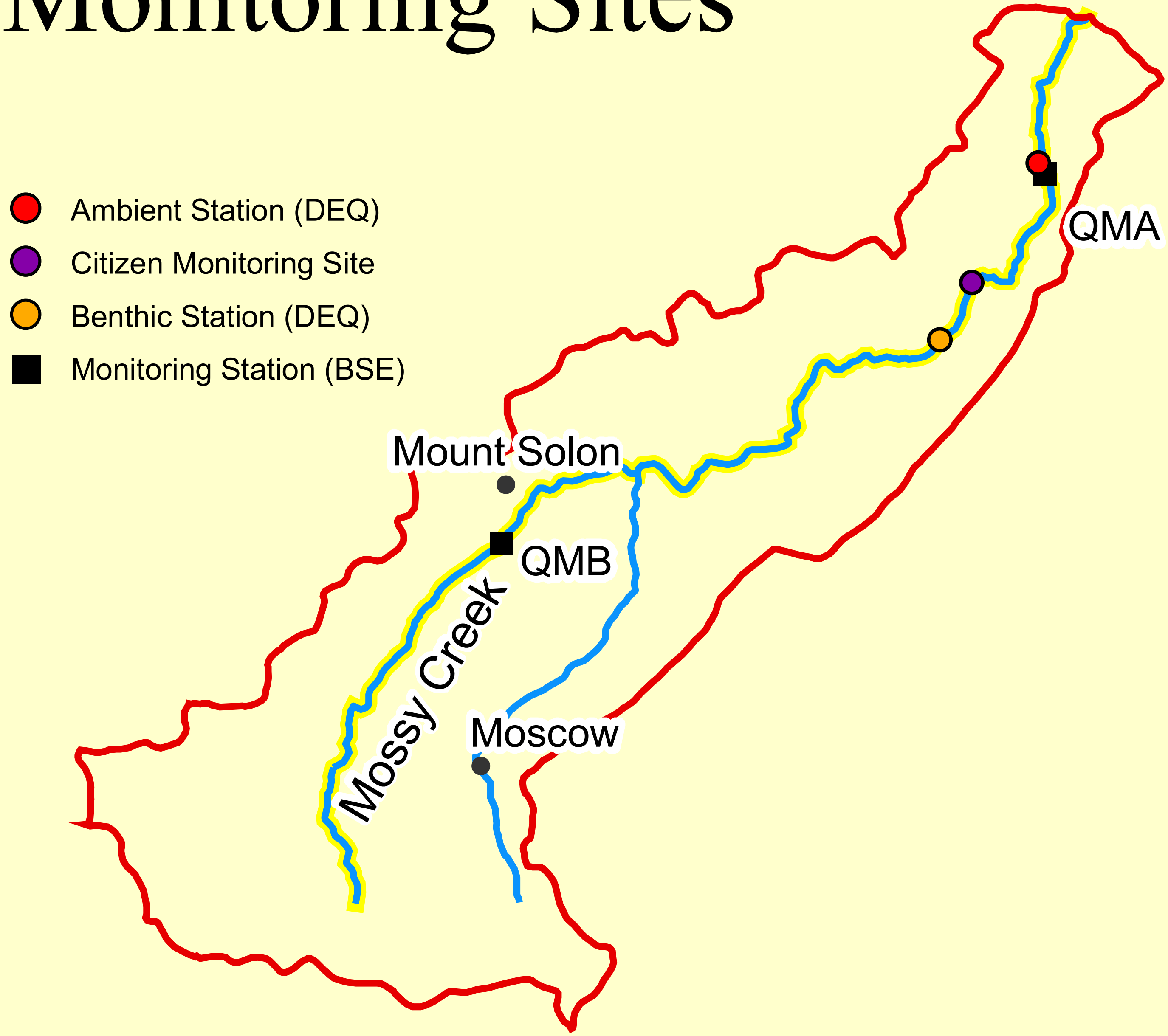
- Uses the Rapid Bioassessment Protocol (RBP II) to assess the
  - number,
  - diversity, and
  - pollution tolerance of the organisms

What are Benthic Macro-invertebrates?

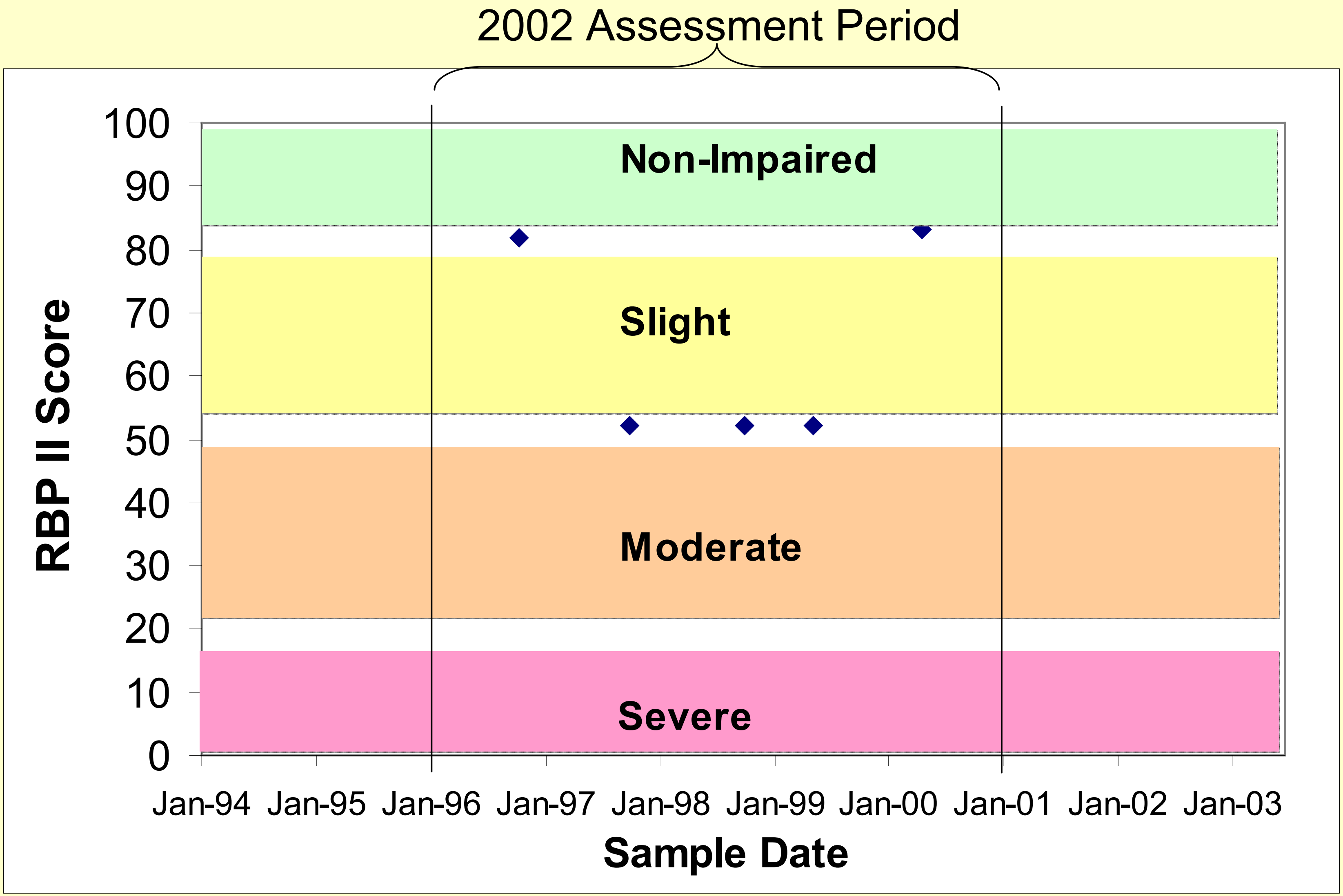
- Stream-inhabiting organisms
  - Benthic: Bottom dwelling
  - Macro: Large enough to see with naked eye
  - Invertebrates: Without backbones

Monitoring Sites



Mossy Creek RBP II Ratings



Benthic Stressor Analysis Procedure

- Identify potential stressors
- Collect and analyze available data for each potential stressor
- Select the most probable stressor(s)
- Develop the TMDL for the selected stressor(s)

Stressors Considered

- Sediment
- Organic Matter
- pH
- Toxics
- Nutrients
- Temperature

Possible Stressors

- Sediment
- Organic Matter
- pH
- Toxics
- Nutrients
- Temperature

Nutrients as a Stressor

- Average nutrient concentrations sufficient for eutrophic growth
- Some algal growth observed
- Poor riparian forest cover

PRO

- No monitored exceedences of TP “threatened” criteria
- Nutrient concentrations less than reference
- No DO violations
- Generally good riparian vegetation

CON

Organics as a Stressor

PRO

- *Hydropsychidae* dominant in all but 2 samples
- Moderate MFBI metric scores
- Repeated presence of *Asellidae* in low numbers
- Potential from livestock manure in riparian pastures

CON

- Low values of DEQ-reported TOC, %VS, BOD_5, and COD concentrations
- Low TKN (organic fraction) as %Total N
- Ambient DO all above minimum WQS of 5 mg/L

Sediment as a Stressor

- TSS concentrations higher than reference
- Increases in embeddedness, sediment point bar formation, and channel modification (Habitat Evaluation)
- Pastures with livestock stream access
- Increasing fines deposition and streambank erosion

PRO

- Presence of low numbers of Elmidae, a species not tolerant of high sediment concentrations
- Good proportion of scrapers, indicating availability of clean rocky substrate

CON

Sediment = Most Probable Stressor

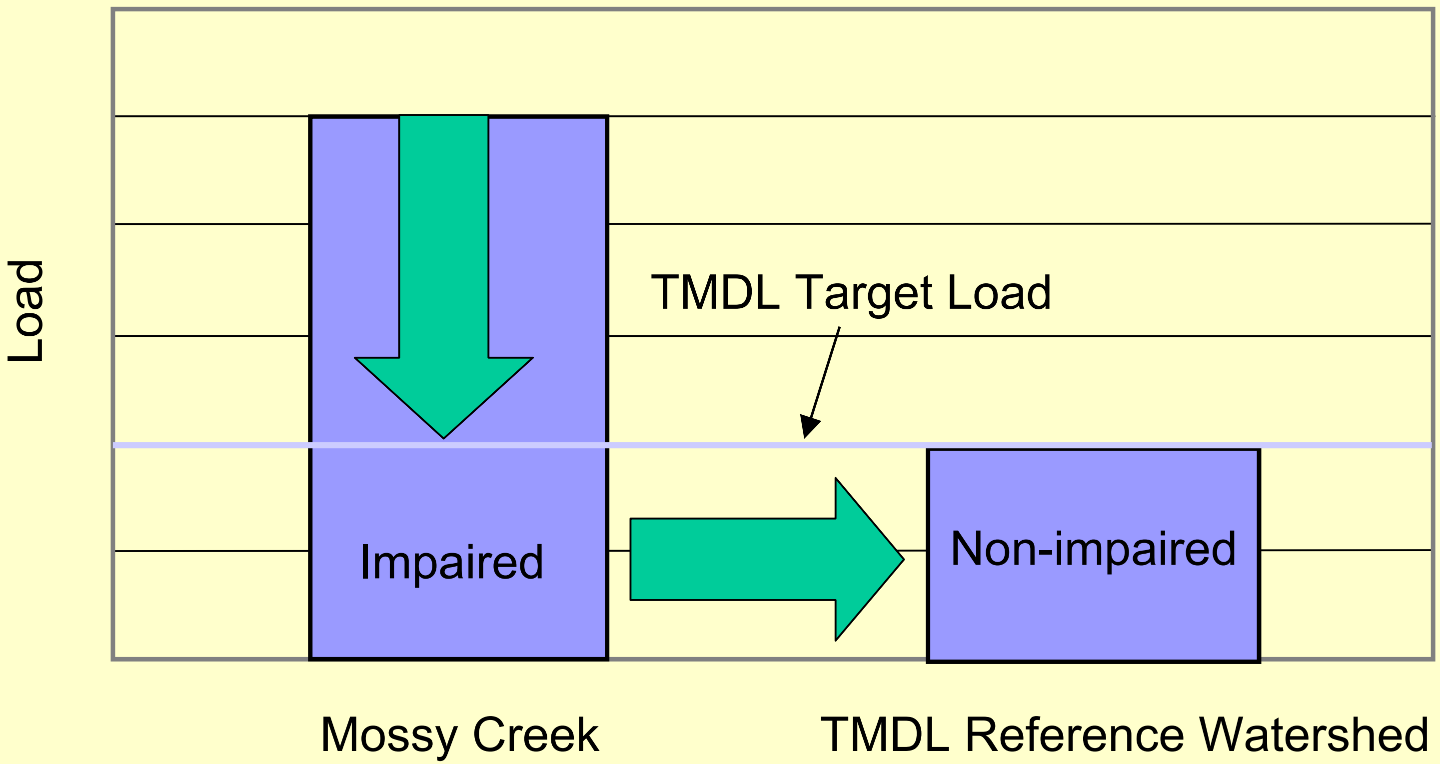
- Impacts from the three possible stressors – nutrients, organic matter, and sediment – are probably inter-related.
- BMPs employed to control sediment would also decrease nutrient and organics loadings.
- The ultimate criteria for the TMDL will be the restoration of the benthic community itself – staged implementation.

Using the **Reference Watershed Approach** to Develop a **Sediment TMDL**

Reference Watershed Approach

- Used in place of a numeric standard
- TMDL Reference Watershed
  - Has a healthy benthic community (non-impaired)
  - Similar characteristics to impaired watershed
- Establish basis for load comparisons
- Simulated load from Reference Watershed becomes the TMDL load

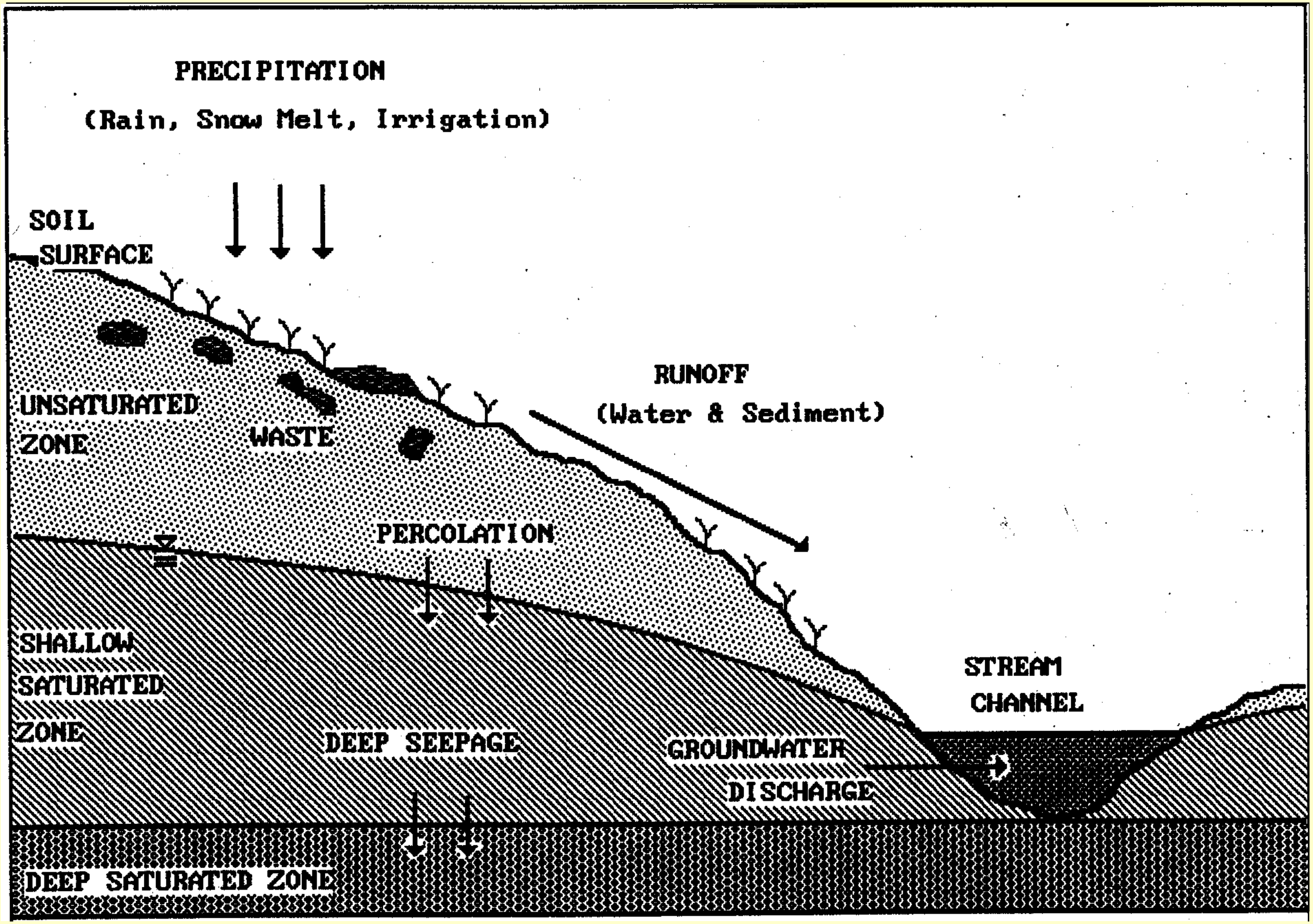
Example Benthic TMDL



Reducing the load in the impaired watershed is expected to restore the benthic community

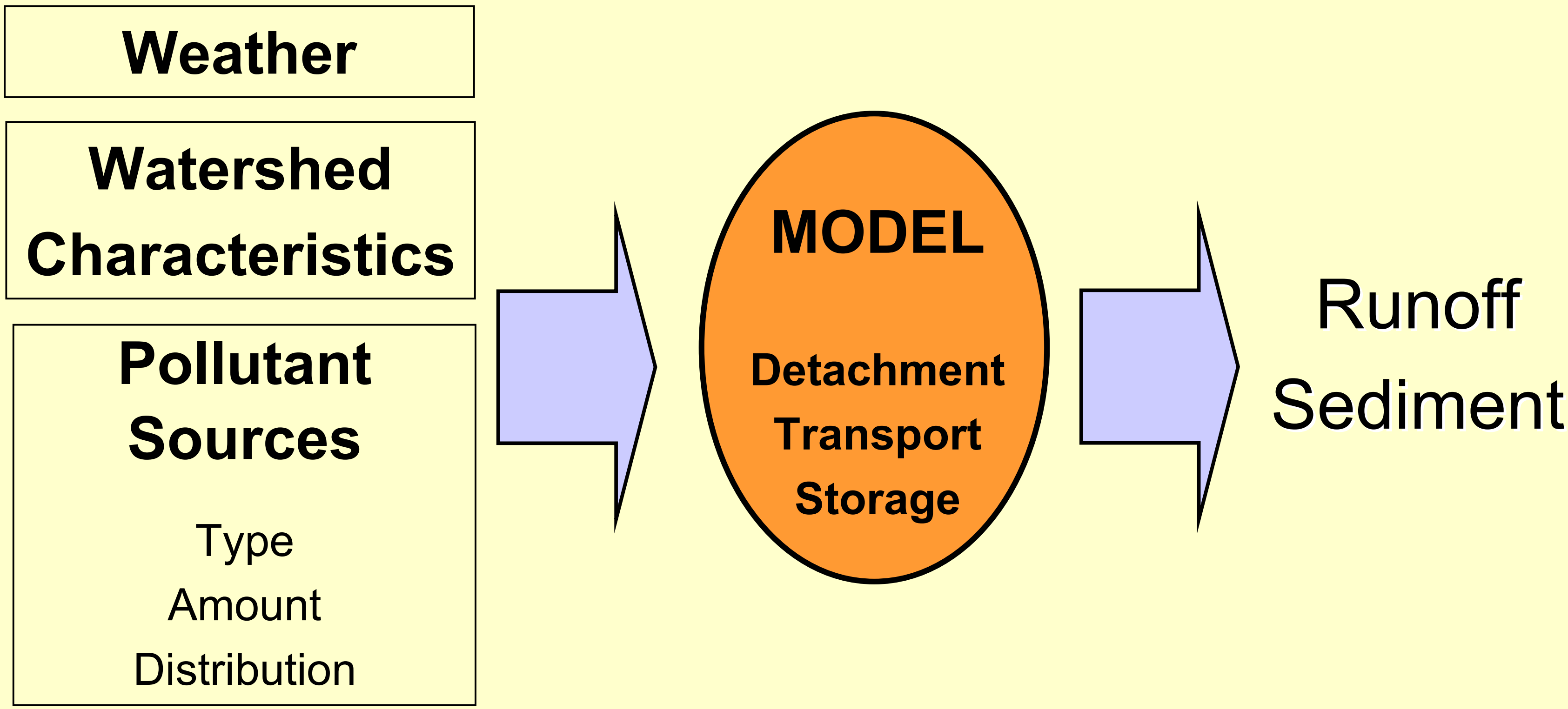
Modeling Sediment Loads

The GWLF Model



The Modeling Process

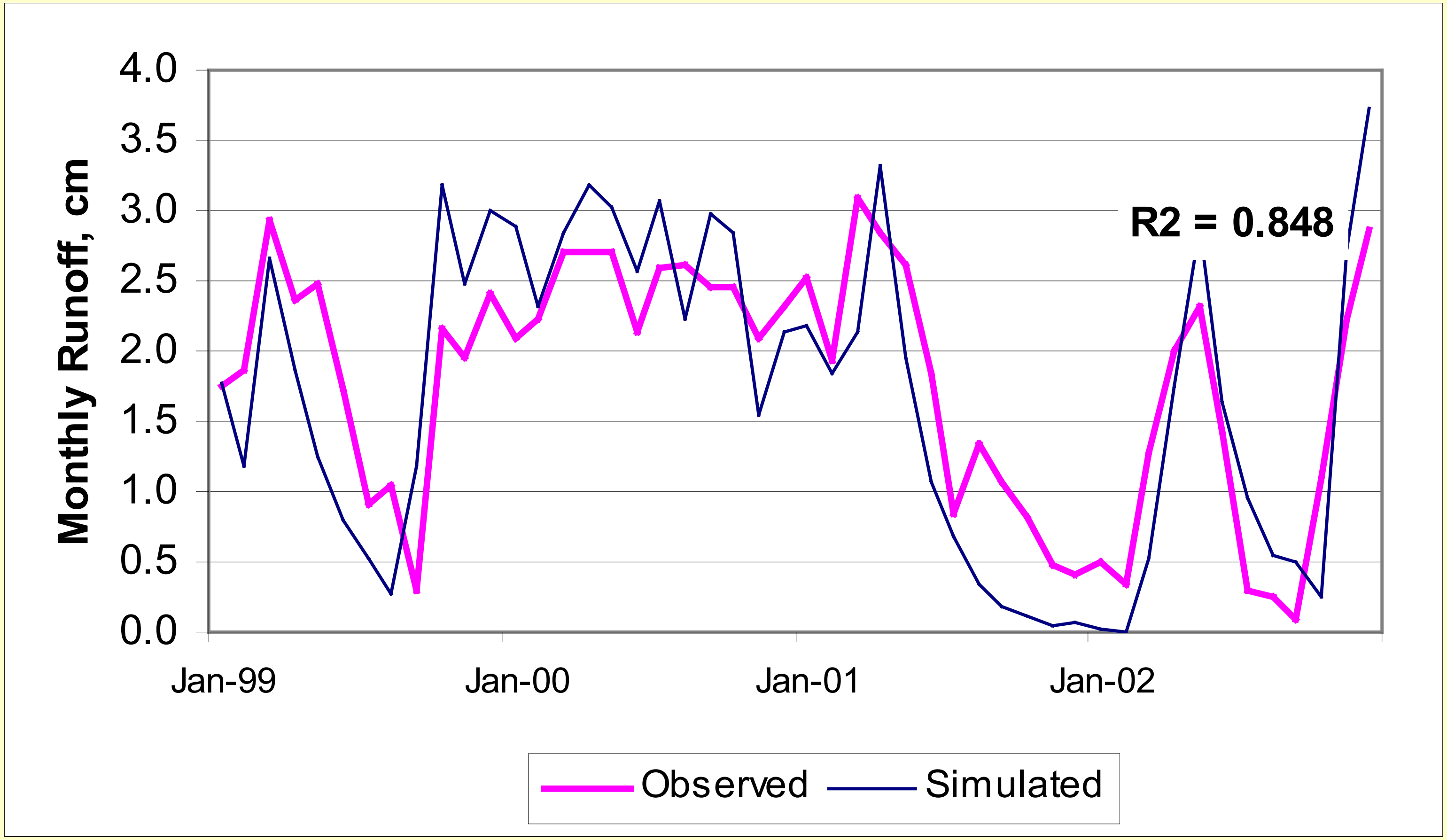
- Define Inputs
- Model defines relationships
- Generate Outputs



Sediment Sources

- Soil erosion
- Impervious area wash-off
- Suspended solids from permitted sources
- Channel erosion

Calibrated Monthly Runoff Time Series



GWLF Hydrology Calibration for Mossy Creek

- Base Flow – recession coefficient
- Seasonal Distribution – composite ET cover coefficients for Dormant and Growing seasons, and available soil water content

Flow Distribution Components	Simulated (cm/yr)	Observed (cm/yr)	Sim-Obs (cm/yr)	(Sim-Obs)/Obs (% of Total)
Total Runoff	20.32	21.35	-1.03	-4.8%
Winter (Dec-Feb) Runoff	4.36	4.59	-0.23	-4.9%
Spring (Mar-May) Runoff	6.85	7.50	-0.65	-8.7%
Summer (Jun-Aug) Runoff	3.67	4.26	-0.59	-13.8%
Fall (Sep-Nov) Runoff	4.51	4.29	0.22	5.2%

Existing Sediment Load – Mossy Creek

Surface Runoff Sources	Mossy Creek (t/yr)	Mossy Creek (t/ha-yr)	Mossy Creek (%)	Upper Opequon Creek (t/yr)	Upper Opequon Creek (t/ha-yr)	Upper Opequon Creek (%)
High Till	8,455.0	52.2	41.5%	1,825.2	14.6	32.1%
Low Till	9,166.5	23.0	45.0%	826.7	8.7	14.6%
Pasture	1,358.0	0.5	6.7%	730.1	0.4	12.9%
Urban grasses	0.0	0.0	0.0%	113.3	1.2	2.0%
Orchards	0.0	0.0	0.0%	16.0	0.1	0.3%
Forest	96.4	0.1	0.5%	79.9	0.1	1.4%
Transitional	16.5	9.2	0.1%	289.1	15.0	5.1%
Pervious Urban	65.1	0.5	0.3%	49.1	0.2	0.9%
Impervious Urban	0.0	0.0	0.0%	120.8	0.6	2.1%
Other Sources						
Channel Erosion	1,227.2		6.0%	1,628.2		28.7%
Point Sources	0.04		0.0%	2.5		0.0%
Watershed Totals						
Existing Sediment Load (t/yr)	20,385.0			5,680.8		
Area (ha)	4,071.2			4,071.2		
Unit Area Load (t/ha-yr)	5.007			1.395		
Target Sediment TMDL Load				**5,680.8**		**t/yr**

Target TMDL Sediment Load

- t = metric ton = 1.102 tons

Mossy Creek TMDL Sediment Load

TMDL = WLA + LA + MOS

- TMDL = total allowable daily load
- WLA = waste load allocation (point sources)
- LA = load allocation (non-point sources)
- MOS = margin of safety (10% of TMDL)

TMDL	WLA	LA	MOS
5,680.8	0.04 VAG401083 = 0.04	5,112.6	568.1

TMDL - MOS = Load for Allocation = 5,112.7 t/yr

Sediment Allocation Scenarios

- All reductions from largest source category - Cropland
- Equal % reductions from 3 largest source categories
- Equal % reductions from all source categories

No reductions from permitted point sources

Mossy Creek TMDL Allocations

Source Category	Reference Upper Opequon (t/yr)	Existing Mossy Creek (t/yr)	TMDL Sediment Load Allocations: TMDL Alternative 1 (% reduction)	TMDL Alternative 1 (t/yr)	TMDL Alternative 2 (% reduction)	TMDL Alternative 2 (t/yr)	TMDL Alternative 3 (% reduction)	TMDL Alternative 3 (t/yr)
Cropland	2,667.9	17,621.5	86.7%	2,349.2	75.6%	4,303.2	74.9%	4,419.6
Pasture	730.1	1,358.0	0%	1,358.0	75.6%	331.6	74.9%	340.6
Urban	572.3	81.7	0%	81.7	0.0%	81.7	74.9%	20.5
Forestry	79.9	96.4	0%	96.4	0.0%	96.4	74.9%	24.2
Channel Erosion	1,628.2	1,227.2	0%	1,227.2	75.6%	299.7	74.9%	307.8
Point Sources	2.4	0.04		0.04		0.04		0.04
Total	**5,680.8**	**20,385.0**		**5,112.7**		**5,112.7**		**5,112.7**

11.6% of the existing Channel Erosion load will be reduced from BMPs implemented for the concurrent bacteria TMDL

What's Next?

- TMDL Report available for review:
  www.deq.state.va.us/tmdl/tmdlrpts.html

- 30 day public comment
- Make appropriate changes
- Submit report to EPA for approval
- Develop an implementation plan

Acknowledgements

- Residents of the watershed
- Agricultural producers
- Bob Cramer, Mossy Creek Lodge
- Headwaters SWCD
- Virginia Department of Environmental Quality (VADEQ) - Bill van Wart

Contact Information

For Questions or Comments, please contact:

Brian Benham
209 Seitz Hall (0303)
Blacksburg, VA 24061

Phone: (540) 231-5705
Fax: (540) 231-3199
Email: benham@vt.edu

Gene Yagow
307 Seitz Hall (0303)
Blacksburg, VA 24061

Phone: (540) 231-2538
Fax: (540) 231-3199
Email: eyagow@vt.edu